





The salt marsh plants of Brooklands Lagoon

An identification guide

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Preface

This identification guide was written as part of a New Zealand Science, Mathematics and Technology Teacher Fellowship (2008) that involved an extensive vegetation survey of all the salt marsh wetlands at Brooklands Lagoon. Although very worthy plant identification references already exist that cover salt marsh plant species in New Zealand, it was felt that a booklet that was dedicated to the significant plants of the Brooklands Lagoon salt marsh, would be a useful resource for ecology teachers and pupils, as well as interested members of the local community. Some of the information came from personal observations, some resulted from valued discussions with Christchurch City Council botanist, Dr Trevor Partridge, and the rest from the reference books listed below (or in the introduction). One of the problems with any publication involving plants is the inevitability of species name changes, and even classification changes. The most reliable reference for current species names is the Landcare Research website[1], and in time some of the species names used in this booklet will be out of date.

The research was driven by a need for detailed vegetation data, and a desire by Christine Heremaia, representing the Styx Living laboratory Trust, for schools and the community to be more actively involved in the future of Brooklands Lagoon. An environmental monitoring booklet will be written to enable schools not only to collect vegetation, salinity and sediment data over the next five years, but also to update the information on the Styx website. Both booklets can be downloaded from the Styx website in 2009[2].

All photographs in this publication were taken by Graeme Worner.


Christ's College biology teacher, Graeme Worner, at work in 2008

Valuable plant species reference resources

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McCombs K (1993) *Estuarine and Freshwater Plants in Christchurch* CCC publication

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1 *www.landcareresearch.co.nz*

2 *www.thestyx.org.nz*

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Introduction

One of the great joys in life is exploring wild places that have managed to retain a natural integrity, despite the encroaching influence of man. The three salt marsh ecosystems around the margins of Brooklands Lagoon present an excellent opportunity to explore, in relative comfort, close to the city.

Being able to confidently identify plant species and notice the subtle variations in size, colour and growth form of individual plants is very satisfying, and is the first step in coming to grips with the natural order and patterns within the salt marsh ecosystem.

2.1 Brooklands 'estuary'

Brooklands Lagoon, despite its rather romantic name, is actually a very elongated estuary, with the Styx River emptying into it, and the Waimakariri River flowing past the entrance. An estuary is a semi-enclosed coastal body of water with one or more rivers or streams flowing into it, with a free connection to the open sea[1]. Because of its position at the mouth of a river, an estuary on the flat Canterbury Plains will tend to form large expanses of mudflats from the sand and fine river silt deposited by tidal action. Depending on the balance of fresh river water and saline tidal flow, the water in the estuary will range from almost 100% sea water (33 ppt) to only slightly brackish water.

2.2 Salt marsh wetlands

A salt marsh is a wonderfully natural, but structured, wetland ecosystem that is generally able to resist the invasion of exotic plant species ('weeds') by being a tough place to live. Science or biology lessons at high school will have mentioned the principle of osmosis, and how animals and plants need to keep their cell fluid concentrations within very precise limits. The presence of salt water causes major osmotic[2] stress, and unless organisms have special adaptations to cope in a saline environment, they will lose huge amounts of water, dehydrate and die. Even if plants can tolerate a salty environment, it comes at a cost, and they will have to expend a huge amount of the energy normally put into growth and reproduction, just to survive. The bonus for these special salt-tolerant plants (or halophytes) is a lack of competition from other plant species.

2.3 The salt marsh vegetation

At Brooklands Lagoon, only one species of woody shrub can tolerate the salty environment, and then only at the upper margins of the salt marsh. The remaining 30-odd species are herbaceous, either perennial (surviving for more than one year) or annual. Some of the perennials are winter-green, present all year round to enjoy, but at least half the species die down in the winter, re-emerging in the late spring. During October and November, the salt marsh comes alive with all the new growth and pretty, but small, flowers. It is at this time that the various zones that the salt marsh plants occupy become most obvious. Ecologists call this a zonation pattern, and it reflects the subtle changes in environmental conditions moving from the lower marsh mudflats to the upper marsh bordering on the base of the surrounding sand dunes.

To exist for long periods as a functioning ecosystem, the salt marsh needs a stable substrate, regular input of solar energy, and an abundance of continually recycled nutrients. The wet mudflats of estuaries are incredibly productive ecosystems, because of the shallow, warm, well-aerated water, rich in nutrients and high solar radiation. Seaweeds, microscopic photosynthetic bacteria and diatoms cope best in these conditions, but cannot withstand drying out in between tides. Salt marsh plants colonise the transitional intertidal zone between land and salty or brackish water. They tolerate the drier salty sediments and the partial inundation by the tide, but struggle to reach the same productivity as their marine distant relatives. Only one flowering plant (eel grass or *Zostera novae-zelandiae*) has managed to colonise the lagoon margin itself and there

[1] *aestus is Latin for tide*

[2] *For more information about the principle of osmosis, and active transport (another cellular process important to salt tolerant plants) there is an appendix at the end of this booklet*

is generally a large expanse of bare mudflat before the salt marsh colonizing species typically appear.

2.4 The Geography of Brooklands Lagoon

Brooklands Lagoon is unusual in having such a long narrow shape. It is about 4.5 km long (in a north-south direction) and somewhere between 250m and 650m wide[3]. The eastern shore of the lagoon is separated from Pegasus Bay by a sandspit, and the northern end of the lagoon opens into the Waimakariri River only 400m from the sea. The Styx River flows into the lagoon a short distance from the lagoon's confluence with the Waimakariri River. On a spring tide, approximately 1.6 million m^3 of water enters the lagoon, with about 98% of it leaving on the ebb tide. Sediments in the northern two-thirds of the lagoon are predominantly sandy, with the silt/clay content increasing towards the low water. At the southern end of the lagoon the silt/clay percentage increases markedly.

2.5 Recent History of Brooklands Lagoon

The most unusual shape of the estuary at Brooklands is due to the Waimakariri River mouth shifting north 68 years ago. Until 1940, the Waimakariri River flowed through what is now Brooklands Lagoon, and out to sea through a large mouth, two-thirds of the way along the spit. Some local residents remember tying up their boats at the river mouth close to the present northern end of Spencer Park[4]. In 1930, engineers dug away at the sandhills to create a new direct course to the sea for the Waimakariri River. Over 1000 ten-tonne concrete blocks were set up to stabilise what they expected to be the new mouth. This was one of several measures taken to reduce the risk of flooding. When the cut was opened in 1931 however, the Waimakariri continued to flow through the lagoon. It was not until the river flooded in 1940 that the mouth shifted 3 km north to Kairaki, helped along by some excavation, but it did not use the designed channel, and the concrete blocks lie buried by sand some distance south of the present mouth.

Originally the whole coastline between the Avon-Heathcote Estuary and the Waimakariri River was a 2428 hectare farm called 'Sand Hills Run'. This had a huge impact on the protective sand dunes and it is recorded that even by the 1870s, the native shrubland, pingao and spinifex grass had been stripped by rabbits, sheep and cattle, and invaded by weeds.

European settlement also significantly changed the flow of the Waimakariri River. Forests and tussock land in the upper Waimakariri catchment were burnt off, over-grazed and cleared. Such clearing caused 20–50 % more water to wash into the river causing greater flooding as well as carrying far more sediment to the coast.

2.6 The ever-changing sediments

The lagoon itself has undergone great change. When the Waimakariri River mouth shifted north, the southern part of the estuary was cut off from the scouring effect of strong tides and the main river channel, and began to gradually fill in. During flood events, sediment-laden Waimakiriri river water enters the lagoon and the bed of the lagoon is covered with a few mm of fine silt. This deposited mud is typically resuspended by wave action and tidal water movement and much is removed from the lagoon by the out-going tides[5]. As tidal flows are greater at the lagoon mouth, more mud mobilisation and removal occurs from the northern parts of the lagoon than further into the lagoon. Consequently, the infilling of the lagoon has progressed from the southern end,

[3] ***Marsden, I.D & Knox, G.A***. *(2008) Estuaries, harbours and inlets. pp. 735–770 in The Natural History of Canterbury. Edited by M. Winterbourn, G. Knox. C. Burrows & I. Marsden. Canterbury University Press*

[4] ***Owen, S-J***. *(edit.) (1992) The Estuary: where our rivers meet the sea. Christchurch's Avon-Heathcote Estuary and Brooklands Lagoon. Chapter six: The last 150 years–the effect of urbanisation. (Produced by the parks unit, Christchurch City Council) Batyprint NZ Ltd*

[5] ***Hicks, D. M. & Duncan, M. J.*** *(1993) Sedimentation in the Styx River catchment and Brooklands Lagoon. A report to the Christchurch City Council & Canterbury Regional Council. Miscellaneous Report No. 128 NIWA (freshwater division)*

with the net deposition expected to build to the north as the shallow mudflats are gradually transformed to marsh. Since 1969 the average rate of sedimentation within the lagoon has been about 3 mm per year on average, with recent, unpublished estimations showing the greatest deposition occurring in the Pikelets region. Interestingly the older three square pikelets of South Spit and Middle Spit have been significantly eroded, and in many cases the vegetation has disappeared completely, suggesting the region is very dynamic.

As the lagoon becomes shallower, the clumps of rushes trap the sediment and spread outward, further reducing the amount of open water. Salt marsh plants become established, first on the lagoon margins, then on the built-up rush islands in the previously open lagoon. The southern lagoon, previously mudflats, is slowly turning into a coastal saltmarsh, with some indication of freshwater ponding and colonisation by raupo and other native species of similarly low salt tolerance.

The ecological conditions in estuaries are both complex and extreme, because of the twice-daily flooding at high tide, and the emergence of much of the floor of the estuary at low tide. At high tide some low-growing plants are completely immersed, and others are partially so. Water levels vary according to the spring versus neap tides, and may vary daily as a result of differences in windiness and wave heights, as well as changes between flood and low water episodes in inflowing rivers and streams. Plants that live in these conditions have to cope with these variable factors of oxygen deprivation when they are under water, and heat and drying at low tide.

Lagoon plants that are always submerged are subject to the most even conditions. At Brooklands, the saltiest places are where summer evaporation of pools of brackish water concentrates salt, which may rise to much higher amounts than are found in sea water. Salt crusts sometimes form on the soil surface. Such salt pans are generally devoid of vegetation.

2.7 Salt tolerant plants

Sea rush, a common salt marsh species with a lower tolerance to salinity, can survive happily in marginal lower-lying areas with 30 cm of tidal water surrounding it for long periods, but cannot compete in areas a long way from the influence of the tide, where the sediments are coarser and the salinity range may be significantly greater. In contrast, succulent species such as glasswort, thrive on the dry, often highly saline, mounds of coarse sediment. Out by the lower margin of the salt marsh, in coarser sediments, any areas slightly raised by as little as 10 cm, will be colonized by sea primrose, with sea rush occupying the neighbouring lower-lying areas. Sediment size obviously plays a huge part in determining salinity ranges, but for one species, the three square sedge, the very finest sediments with poor drainage lead to waterlogged, anaerobic conditions that suit it perfectly with its huge air spaces in the stems. Three square sedge therefore becomes the dominant lower marsh colonizer of the fine sediments, present mostly in the southern part of the lagoon.

2.8 The naming of species

The systematic classification and naming of plant species is called taxonomy, and began in 1735 with the publication of Systema Naturae by the Swedish botanist, Carl Linnaeus. The formal classification of each species is complex, and reflects the evolutionary history (or phylogeny) of the species. Every taxonomist in the world uses two latin words to name a species. The first word (the genus or generic name) classifies the species in the same way a human surname does, while the second (the species or specific name) clarifies exactly which of that group is being referred to (similar to a Christian name). Many of the rush species in New Zealand belong to the genus, *Juncus*, but each species has a different second name to distinguish them e.g *Juncus kraussii, Juncus caespiticius, Juncus pallidus*. Each has a common name, and in a lot of cases, a Maori name, e.g. *Apodasmia similis,* is also called jointed rush or oioi. Unfortunately, the common names can prove to be unreliable, as around the country, and overseas, the common

names have been made up for convenience, and often different species inadvertently may be referred to by the same common name. Just as inconvenient is the fact that the same species may have several common names e.g. *Sarcocornia quinqueflora* is known as glasswort (of which there are many species around the world) and sea asparagus. Taxonomists sometimes refer to species simply by their generic name, which is fine providing only one species of that genus is normally found in the area being studied. That is a safe assumption at Brooklands Lagoon, and it is just as normal to refer to the salt marsh species as *Juncus* or *Selliera*, or *Apodasmia*, as it is to use the common names of sea rush, remuremu and oioi.

Written formally, the scientific name of any species follows one of two conventions. In print, the latin scientific name is written in italics with a capital letter for the genus and a lower case letter for the species name. In a handwritten document, the convention is the same except the genus and species names are underlined separately rather written in italics.

Sometimes, two species belonging to a genus appear to have three latin names. The third is a subspecies name and indicates that although the two species are presently classified as belonging to the same species, there are enough differences in appearance and habitat distribution, to consider them as being partially separate species. They are still capable of successfully reproducing together, so must by definition, be considered to belong to the same species, but by distribution they may be isolated from each other, so interbreeding is normally impossible. By listing a subspecies, taxonomists are predicting that in time, separate species will form. e.g. the common sea rush is formally known as *Juncus kraussii* var. australiensis.

2.9 The advantages of using a key

A taxonomist would follow through a carefully formatted key to identify an unfamiliar plant species, rather than rely on photographs or drawings that can easily be misinterpreted. In general, anyone else is often put off by the formal nature of a key and the fear that lack of the appropriate scientific vocabulary will ultimately be frustrating. Using a key however, can enhance the observation of specific features of the plant that ordinarily may go unnoticed. It also gives a great insight into which features out of thousands, can be readily used in the future to distinguish similar species. Looking at a photograph of a plant does not confirm that it is the species you are trying to identify, and a similar looking species may be grouped with it inadvertently… until you have noticed the differences between them!! While using a key it is impossible not to notice the number of plants that may look superficially similar, and then be wary of lumping them together.

The key included here is designed to contain only the common species found at Brooklands Lagoon in the salt marsh itself. In the upper marsh boundary with the sand dune vegetation, several exotic invasive species not found in the key, may be encountered (e.g. gorse, broom, hawksbeard, tares). They will not be able to tolerate the salty conditions long term and should be ignored. It may, however, be an early sign of a changing habitat that has lost its tidal contact. In the extreme southern end of the lagoon adjacent to Spencer Park, some species not described in the key may be found (e.g. broad-leaved plantain, giant rush) These are freshwater wetland plants that are not tolerant to saline conditions, and indicate that already the southern tip of the salt marsh is a ponded freshwater habitat.

2.10 How to use this key

Each step in the key is numbered, and offers two options[6]. The choices should be straightforward to decide between by examining the specimen. Pictures included should clarify the options. Any vocabulary that may be confusing is listed at the bottom of the page in the footnotes. The choice you make has a 'go to' number. As in Monopoly, 'go directly to that number, do not stop at any steps in between'. By following the 'go to'

[6] *Taxonomic keys offering two choices at each step, are called dichotomous keys*

numbers after each choice, eventually there will be a species name and photograph. If the choices have been made correctly and the wording in the key is not ambiguous, the species should match your 'unknown' specimen. Each of the steps in the process should be regarded as the key features to look out for in the identification of that same species in the future. The key aims to avoid characteristics that may be easily confused, or are too variable to be of any use. The final step in successfully 'keying out' a specimen will often contain a description of the plant with colour shades, seasonal changes, flower shape and fruit/seed shapes, all of which are often unreliable in the main body of the key, but are great for confirming you have the right name for the species.

2.11 Classification of the salt marsh plants

All the salt tolerant plant species belong to the large group of modern plants known as the Angiosperms, or 'flowering plants'. All have flowers, but the flowers do not have to be colourful, large and easily recognised. Flowers are special structures that use either wind or animals to distribute pollen during sexual reproduction. As a rule, insect-pollinated flowers are larger and more colourful, but in contrast, most wind-pollinated flowers, such as those of the grasses and rushes, are tiny and lacking in bright colours. A special feature of many Angiosperms is the presence of bisexual or hermaphroditic flowers, possessing both male and female sex organs. But it is the end product of angiosperm sex, that is most significant though for this highly evolved group. All Angiosperms produce seeds enclosed or attached to a specialised dispersal mechanism, the fruit. It surprises most people to learn that a fruit does not have to be fleshy or taste nice. Most of the fruits of the salt marsh species are small, hard to see and generally dry and hard, aiding the dispersal of the seeds by floating on the water.

2.12 Other major groups of land plants

Apart from the Angiosperms, there are three other important types of plants, but none are represented in a normal salt marsh ecosystem. The Gymnosperms (or conifers, such as pine trees), are characterised by having cones, not flowers. Gymnosperm literally means 'naked seeds', and all conifers produce seeds with no specialised dispersal mechanism apart from a flimsy scale. The seeds merely drop passively from cones to the ground, perhaps aided by wind currents.

The Pteridophytes (ferns) produce microscopic spores, not seeds, but do have specialised and strengthened water and food conducting vessels inside their stems like the seed plants. This important feature allows the largest ferns to grow a trunk, and all ferns can absorb water reasonably efficiently from the soil and transport it throughout the plant.

The Bryophytes[7] (e.g. mosses) produce spores like ferns, but generally lack any veins and transporting vessels inside their stems, so must grow in extremely damp places absorbing water directly through all surfaces.

Apart from the exotic wilding pines that appear to be establishing in the upper marsh fringes of North Spit, it is notable that no groups of plants other than the Angiosperms have managed to colonise the salt marsh.

It really is a tough place to eke out an existence.

[7] *Bryophytes are the most primitive of all the land plants and contain not only the mosses, but also a large group called the Liverworts.*

Identification key

This key has been designed to be used by non-botanists, but some use of botanical terms is unavoidable. As a consequence there are some important decisions that may require you to check the footnotes when indicated. In particular, the very first step in the key involves a decision about the presence or absence of leaves. Only the four salt marsh species listed on this page below, do not have true leaves. You may like to 'cheat' and check the detailed photos of each, to eliminate them when moving past this step.

Normally a key is designed to identify the most common species at the start of the key. In this case because of the extreme diversity in the plant groups present, the aim was to produce a key that is least likely to produce error in identification, even if it meant identifying the less common species first. At each step where a species is identified (or 'keyed out'), a description of the plant is given plus a page reference to a fuller description of appearance and distribution (plus several photographs). If the description or photographs do not match the species you have found (and if the species appears to be reasonably common in the salt marsh), you may have misinterpreted one of the earlier steps in the key. You should then either work backwards to the point where the mistake occurred, or start from the beginning again. Some of the steps in the key are very significant (especially step 1!), and will lead off in markedly different directions. Take the time to read all footnotes, and justify each step in the identification process.

1.	Leaves absent[1] and reduced to scales	go to 2	
	Leaves present	go to 5	
2.	Scale-like leaves along stem	go to 3	
	Scale-like leaves confined to the base of the stem	go to 4	
3.	Stem is succulent, a blue-green colour. Small yellow flowers may be visible in depressions along a lumpy-looking stem.	**glasswort**	p25
	Stem is not succulent, with distinct bands visible every 8–10 cm along stem. Colour varies from a yellow-brown to a pinky-orange	**oioi**	p21
4.	Stem is triangular in cross-section, is a grey-green colour, and has a pointed bud-like cluster of scale-protected flowers near the tip.	**three square**	p20
	Stem is circular in cross-section, is a yellow-lime green colour, and has a spherical cluster of flowers near the tip	**knobby club rush**	p31

[1] From a strict botanical viewpoint, leaves branch from a stem. In some species, especially the succulents, rushes, and sedges, there are no true leaves, or the leaves are reduced to scales. In some succulents, the stem becomes swollen and leaf-like, taking on the photosynthesis function, whereas in rushes and sedges, a green structure (culm) that bears the flowers, looks like a cylindical or triangular leaf.

5.	Stem obviously dark and woody, with tangled, divaricating branches[2]. Obviously shrub-like	**marsh ribbonwood**	p27
	Stem non-woody	go to 6	
6.	Leaves narrow and strap-like, generally 10 cm long but only 0.6 cm wide, very dark green with a distinctive seaweed-like appearance, always lying flat on the surface of the mud	**eel grass**	p51
	Leaves not narrow and seaweed-like, and not lying flat on the mud surface	go to 7	
7.	Leaves form a distinct rosette, with the only aerial portions being flower stalks. The narrow leaves have 2–4 obvious pointed lobes giving an 'antler-like' appearance near the tip. When growing in the shade the leaves can be up to 25 cm long, with the rosette curling upwards. In extremely exposed positions, the rosettes are reddened, and small	**buck's horn plantain**	p24
	Leaves do not form a rosette	go to 8	
8.	Leaves at least 10 times longer than wide	go to 9	
	Leaves less than 10 times longer than wide	go to 25	
9.	Leaves always wider than 15 mm	go to 10	
	Leaves always less than 15 mm	go to 11	
10.	Leaves distinctly V-shaped, extremely fibrous not spongy, with pointed tips. Leaves may be up to 2 m long and 8–10 cm wide. Damage to the leaves by grazing insect larvae may be obvious	**swamp flax**	p38
	Leaves strap-like with rounded tips, approximately 10–20 mm wide, up to 1 m long with a distinctive bullrush seed head. Will die back in winter	**raupo**	p46

[2] *Divaricating shrubs are common in Canterbury. The almost 'dead-looking' tangled branches, and small inconspicuous and inaccessible leaves, are thought to be related to reducing damage to the juvenile stage by frost, wind, and browsing animals. Even common trees such as the kowhai and ribbonwood have a divaricating stage before they mature.*

11.	Leaves completely cylindrical	go to 12	
	Leaves flattened but possibly rolled inwards to form a semi-cylindrical shape	go to 14	
12.	Leaves soft, 'chives-like', always able to be easily pulled or torn in half	**arrow grass**	p37
	Leaves fibrous and strong, not able to be pulled in half	go to 13	
13.	Possesses cylindrical leaves that are > 20 cm long, and dangerously pointed. The most common clump-forming rush at Brooklands, producing distinctive clusters of blackish seeds in summer	**sea rush**	p19
	Possesses cylindrical leaves that are normally only 3–8 cm long, bright lime-green, wiry (<0.5 mm in diameter). The leaf base is an obvious red-purple colour, and each flower stalk has a small inflorescence about 5 mm from the tip	**dwarf cushion sedge**	p32
14.	Flowering stalks are obviously triangular	go to 15	
	Flowering stalks are cylindrical	go to 16	
15.	Grows in distinct tufts, tussock-like, with very narrow v-shaped semi-'cutty' leaves that often curl over and trail 'hair-like' on the surface of the sand or mud	**shore sedge**	p28
	Grows in large, very upright, distinctively bright lime-green swards. Foliage dies completely away in winter	**grassy club sedge**	p50
16.	Flower stalk 15–25 cm long, rough, fibrous and rush-like, with a distinctive spherical infloresence[3]. Leaves are bright lime green with softish v-shaped grassy leaves generally no more than15 cm long	**grass-leaved rush**	p51
	Flower stalk is grass-like, able to be easily snapped, and with a variable-shaped (but not spherical) inflorescence	go to 17	

[3] *Inflorescence means a cluster of flowers, which individually may be tiny.*

17.	Leaves rolled inwards	go to 18	
	Leaves flat	go to 21	
18.	Leaves greater than 20 cm long, hairless, tightly rolled with distinct ribs, The leaf sheath[4] is hairless, a brownish purple colour with a very distinctive membranous, pointed ligule[5] (15–30 mm long). Auricles[6] are absent. It has strong, woody rhizomes and numerous fibrous roots	**marram grass**	p47
	Leaves less than 20 cm long	go to 19	
19.	Flowering stem is unbranched	go to 20	
	Flowering stem is branched. The in-rolled leaves are a light bluish-green or pale yellow-green colour, with outer margins that are rough to touch. The leaf sheath is hairless, a light brownish-purple colour and has a small ligule <2 mm long	**salt grass**	p30
20.	Rhizomes[7] present and wiry. The leaves are a bluish-grey colour, rolled with prominent ribs, and give off an aromatic smell when crushed. The leaf sheaths are an obvious maroon-purple colour , but the ligule is tiny (<1 mm). Auricles are absent	**sand couch**	p44
	Rhizomes absent. The leaves are narrow (<1mm), curved, and <7 cm long. Fine prickle-like teeth can be felt on the ribs of the leaf blade. The leaf sheaths are open and purplish. The ligule is tiny (<1 mm).	**sickle grass**	p45
21.	Patch-forming (has spreading stolons[8] or rhizomes)	go to 22	
	Tuft-forming (no stolons or rhizomes)	go to 24	

[4] *A cylindical leaf sheath surrounds the stem of a grass and gives rise to the leaf blade, which angles away from the stem*

[5] *A ligule is a membrane-like tissue or row of delicate hairs typically found in grasses at the junction of the leaf sheath and leaf blade. The ligule appears to be a continuation of the leaf sheath and encircles or clasps the stem as does the leaf sheath.*

[6] *Auricles are lobes that extend horizontally from the base of the ligule, and the junction of leaf blade and leaf sheath*

[7] *Rhizomes are underground stems used for the vegetative spread of the plant. Rhizomes give rise to upright shoots periodically, which can develop into independent plants if separated from the rhizome*

[8] *Stolons are above ground creeping stems that can give rise to new plants vegetatively. The above-ground equivalent of a rhizome*

22.	Plants have surface stolons for spreading. The completely hairless leaf blades are up to 5 mm wide but generally no more than 10 cm long, with no keel. The ligule is well-developed, easily visible (2–6 mm long) but auricles are absent	**creeping bent grass**	p39
	Plants have underground spreading rhizomes	go to 23	
23.	Ligule is 2–3 mm long and has an obvious dense row of hairs. The leaf sheaths are firm and open. The leaves are stiff, flat or slightly inrolled, up to 40 cm long (5–12 mm wide), and hairless. The lower leaf surface is ribbed, and the leaf tip is hard and fine	**cord grass**	p43
	Ligule is very short (0.5 mm) and hardly visible, but the auricles are long and pointed, curling around the leaf sheath. Stomata are generally visible as rows of white dots on the lower surface of the leaves	**couch grass**	p48
24.	Leaves have a soft, velvety feel, are hairy, and a greyish-green colour. The leaf sheath is hairy with distinctive reddish-purple veins on a white background. The ligule is 1–4 mm long, white and hairy also. Auricles are absent, but the leaves do have a distinct keel	**Yorkshire fog**	p53
	Leaves have a rough feel, but are mainly hairless, a distinctive yellow green colour, and broad (but <15mm). The lower leaf surface is glossy, the leaf sheaths are often a brown-purple colour with a small 1–2 mm membranous green ligule. Auricles are visible and have stiff 0.5–1 mm hairs around the margin, continuing onto the margin of the leaf blade. A large tufted grass with a very tall (up to 1.5 m) flower stalk	**tall fescue**	p26
25.	Leaves are compound, with three or more leaflets arranged on a single leaf stalk	go to 26	
	Leaves are simple, with each leaf arising from a separate leaf stalk	go to 27	

26.	Leaves are trifoliate, having three grey-green leaflets all attached to the same leaf stalk. May have a distinctive yellow, legume 5-petalled flower	**yellow lotus**	p35
	Leaves are pinnate[9], having more than three lobed parley-shaped leaflets arranged along the midrib of the elongated leaf stalk. The leaves have a characteristic celery smell when crushed	**native celery**	p36
27.	Leaves are lobed, having protrusions extending from the normal margin of the leaf	go to 28	
	Leaves have no lobes	go to 31	
28	Leaves possess two lobes extending from the base of the leaf	go to 29	
	Leaves are semi-pinnate, with lobes arranged along the leaf and not confined to the base of the leaves	go to 30	
29.	Has an obvious creeping growth form. The leaves are variable in form, distinctly succulent (1–2 mm thick) and leathery in appearance, and possibly only having the two basal lobes on some of the leaves, giving the characteristic goosefoot appearance. Leaves may range in colour from a yellowy-green to a reddish-green.	**glaucous goosefoot**	p49
	Has an obvious upright growth form. The leaves are only semi-succulent, a grey-green colour, with characteristic pencil-line red markings. Each leaf is arrowhead in shape and the upper surface may have a mealy, rough feel	**orache**	p42
30.	Multi-lobed with >10 crenulations (small lobes 2 mm long) evenly spaced around the margin of the leaf. Generally forms mats of 'fern-like' leaves often in the shade of taller plants	**turf daisy**	p33
	Lobes are very elongated and irregular. Generally confined to very wet freshwater areas or shallow ponds. Has a distinctive bronzey-green to lime green appearance and throughout summer, has the characteristic yellow button-like flower	**bachelor's button**	p34

[9] *Pinnate = feather-like or multi-divided features arising from both sides of a common axis.*

31.	Succulent leaves are almost cylindrical and always paired, with an obvious scale/stipule at the base of the pair of leaves. The stem can have a red tinge, and the plant tends to form distinctive circular clumps early summer	**sea spurrey**	p40
	Succulent leaves are not cylindrical in appearance, or paired	go to 32	
32.	Has a creeping stem, on or slightly below, the surface of the sand or mud	go to 33	
	Has a semi-woody stem, always above ground, giving rise to distinct keel-shaped succulent leaves. Superficially it resembles a mini ice plant	**sea blite**	p41
33.	Leaves are distinctly elongated and/or spathulate[10], with a narrow base to the leaf	go to 34	
	Leaves are not obviously spathulate, are small and rounded (<6 mm in diameter), bronze-purple in colour, with some semi-upright stems, and a mauve flower after the beginning of December	**native musk**	p29
34.	The creeping stem is always underground, with lime-green leaves in summer appearing to originate from the sand surface. The leaves are slightly spathulate, and leathery-looking, ranging from 10–30 mm in length. In autumn the leaves will turn very orange-red, before dying off completely	**remuremu**	p22
	The creeping stem is generally visible on the sand surface, regularly giving rise to distinctly spathulate smallish olive-green or bronze coloured leaves (5–15 mm long), each with a very narrow leaf base. May form tiny rosettes of tightly bunched leaves if growing in a salt turf or salt meadow	**sea primrose**	p23

[10] *Spathulate = spoon-shaped, very narrow at the base, widening out to rounded spoon or spatula shape*

Index of plants

The salt marsh plants identified in this guide are not listed alphabetically. Instead the order reflects how common or abundant each species is at Brooklands Lagoon. Some species have a very broad distribution, while others may only be found in a tiny portion of the entire estuary.

4.1 sea rush

The vegetative spread of sea rush rhizomes is very obvious near the edge of a clump.

An unusual feature to look out for is the presence of young sea rush seedlings growing directly out of the existing flowers. This is known as viviparity, and is best known in NZ by mangrove-lovers.

Scientific name: *Juncus kraussii*
Common name: sea rush
Family: Juncaceae

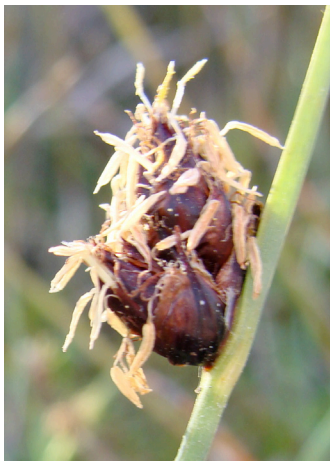
Luckily, sea rush is the only truly salt tolerant member of the large and potentially confusing, rush family. It is a native perennial that forms distinctive clumps. It is instantly recognised by its very dark brown, almost black shiny seeds clustered in the inflorescence on one side of the stem (or culm). The bright green culms are cylindrical (terete), 40–150 cm long, and commonly 2–3 mm in diameter. The tips of the culms are almost always dead, and incredibly sharp (pungent). You may find ordinary leaves which are also cylindical, but have no inflorescence. Avoid eye damage at all costs when investigating around the base of a sea rush clump!

Sea rush can be found from the middle of bare mud flats where it is commonly associated with either sea primrose or three square, to the upper reaches of the salt marsh amongst oioi.

There is often a distinct reduction in height of sea rush as the degree of tidal influence diminishes and the impact of competition with matt-forming plants such as remuremu begins

The only plant that could be mistaken for sea rush is the knobby club rush (*Ficinia nodosa*, previously *Scirpus nodosus*). The two can be easily distinguished as knobby club rush has slightly yellow-green, not so pointed culms, a spherical cluster of flowers 5–10 cm below the end of the stem, and if all else fails, by checking the base of the plant, knobby club rush culms originate singly whereas sea rush typically has a culm (with flowers) *and* a cylindrical leaf.

4.2 three square



Scientific name: *Schoenoplectus pungens*
Common name: Three square
Family: Cyperaceae

In colonising new areas of mudflat, three square may form long zones around the margin of the lagoon, or form round 'pikelet' islands in suitable areas in the middle of the mudflats.

Three square is a triangular sedge, not a rush. It is the only salt marsh species with this distinctive appearance, confirmed by the single small inflorescence near the pointed tip of the stem.

The stems are grey-green and up to 75 cm long, though typically range from 20–50 cm. It is a summer-green perennial herb that is probably the main coloniser of the very fine water-logged clay sediments at the Spencerville end of Brooklands Lagoon. Huge areas of the mudflat are blue-green in summer, and then die back over winter. A significant amount of dead three square is swept around the lagoon and is deposited in large swathes by the tides, often covering existing plant communities.

The ability of three square to survive in almost anaerobic sediment is due to its ability to obtain all the oxygen it needs through the stems which contain huge air spaces. The oxygen easily diffuses to the underground rhizomes.

Three square sward in the Brooklands region, in early summer. Sea rush clumps are dominant in this region.

4.3 oioi

Scientific name: *Apodasmia similis*
Common name: oioi, jointed rush
Family: Restionaceae

Oioi or jointed rush is a native perennial restiad rush, having distinctive bands at 8-10cm intervals up the stems. The leaves are reduced to scales at these joints. The colour is extremely variable ranging from a dull olive green to a bright, almost translucent orangey-red. Spreading with creeping rhizomes, each clump can eventually grow into an ever-expanding circular mass with each stem the same shade of colour as its cloned neighbours. However, oioi that originates from slightly different genetic stock (strain) may be a subtly different colour.

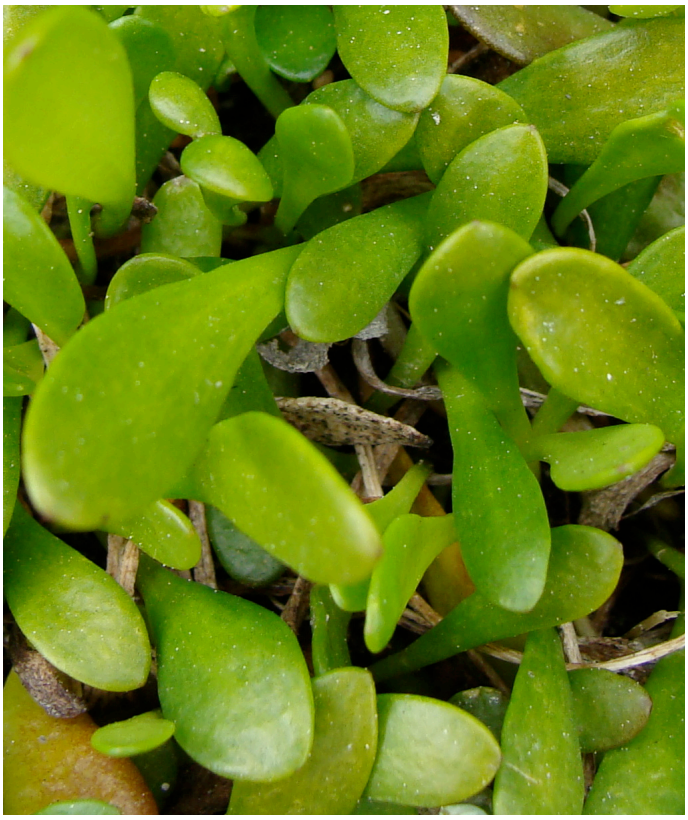
The male and female flowers pictured below, are found on different plants. The narrower male flowers die off after pollen is shed.

Apart from its wonderful common name, oioi simply looks stunning in giant circular patches, with russet tones shown up in the early morning sunlight. That aside, it can be a real pain trying walk through it, when it reaches its full height of 1.4 metres!

Oioi can be found in its round swards out in the tidal region of the mudflats as below, or on higher ground typically as a later stage in the succession of the salt marsh community, with shore sedge or marsh ribbonwood seedlings.

In older areas there are majestic hectares of mostly oioi, with just the occasional sea rush or tall fescue seed head poking through. In the last stage of Canterbury salt marsh succession, the oioi is completely shaded by 2.5m marsh ribbonwood shrubs.

4.4 remuremu



Scientific name: *Selliera radicans*
Common name: remuremu
Family: **Goodeniaceae**

Remuremu is a slightly succulent, summer-green perennial herb, with far-creeping underground stems, that form a dense mat. The numerous yellow-green spathulate leaves are 15–40 mm long and are arranged along the horizontal stem at regular intervals. The leaves may orientate upwards, but the stems are never aerial. The leaves are longer in the shade of taller plants

The flowers are 7–10 mm in diameter, on branched flower stalks (or peduncles), and are not only very pretty with a white to pale blue colour, but unusual in having the 5 narrow petals in a fan-shape.

The oval fruits are 6–10 mm long and contain flattened seeds that have narrow wings, and are notable for being sticky when wet.

In winter the leaves change to an obvious bronze-red colour before dying off completely.

Remuremu is one of only two native species in this family, but in the Canterbury salt marsh it rivals sea rush for the wide range of habitats it is found in, and can be found growing beneath sea rush in areas where the sea rush does not reach maximum growth.

In even drier sediments, remuremu will form dense mats with buck's horn plantain, sea primrose and glasswort or a dense turf with dwarf cushion sedge (as below)

It will surprise you just how common remuremu is, in diverse mid-marsh habitats. It seems to be very tolerant to high salt levels, dry UV-exposed sediments, and extreme shade.

Remuremu and sea primrose mixed!!

4.5 sea primrose

Scientific name: *Samolus repens*
Common name: Sea primrose
Family: Primulaceae

Sea primrose is a perennial summer-green herb with branching stems up to 40 cm long creeping over the sediment.The leaves are a characteristic dull green colour only 7–15 mm long and only 4–6 mm wide (but occasionally larger in the shade), and a narrow spathulate shape. It appears to be similar to remuremu, but is generally much smaller-leaved, and possesses upright stems.

The flowers are small, only 7 mm in diameter, solitary and emerging from the side of the stem. There are five white petals and after flowering, a 5-valved capsular, dehiscent fruit is formed, containing numerous minute seeds.

Sea primrose is the only NZ member of the primrose family, and when it is flowering *en masse* on the mudflats, it is spectacular. It has an unusual distribution, usually being the primary coloniser of coarser sediment mudflats, that are flooded twice daily. However, it can also be found taking advantage of the drier microhabitats in the upper salt marsh. sharing the exposed low growing salt meadows with glasswort, buck's horn plantain, dwarf cushion sedge and remuremu. In contrast it can even be found in the shade beneath tall oioi swards amongst the tiny native celery.

Sea primrose growing near the base of a sea rush clump.

4.6 buck's horn plantain

The leaves of buck's horn plantain can grow significantly longer in the shade of sea rush clumps

Scientific name:	*Plantago coronopus*
Common name:	buck's horn plantain
Family:	**Plantaginaceae**

Buck's horn plantain is an exotic perennial rosette herb. It is instantly recognised because of its radial symmetry, and the long, narrow, relatively floppy hairy leaves that have the characteristic pairs of small antler-like protrusions. It produces large amounts of seeds which allows it to colonise the drier coarser sediments of the salt marsh as well as disturbed habitats, which it often dominates. In spring you will often find swards of seedlings with narrow upright leaves, not assuming the characteristic rosette adult shape because of the density.

A dense rosette in late autumn

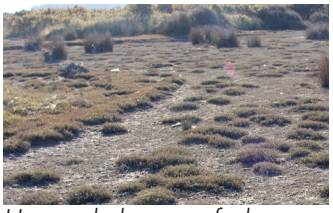
Buck's horn plantain can often be found in open areas of salt meadow growing amongst remuremu as above (also commonly with sea primrose and glasswort)

4.7 glasswort

Scientific name: *Sarcocornia quinqueflora*
Common name: glasswort
Family: Chenopodiaceae

Glasswort is one of only two common native perennial, succulent plants found growing in salt marshes and on coastal rocky outcrops in Canterbury. The grey-green to pinkish fleshy stems (3–5 mm in diameter) are sprawling or erect, forming clumps typically 5–10 cm tall.

An unusual and obvious feature is the many bulbous stem segments each 1–2 cm long, and the yellow anthers that protrude from small slits found near the ends of the stems. The flowers themselves are tiny, and enclosed within the stem. The fruits are dry, brown, cone-like structures, about 8 mm long, growing out of the side of the stems. The seeds have slightly hooked hairs.



Unusual clumps of glasswort and viewed closer

Glasswort is incredibly salt-tolerant (up to 150% SW) and so can be found growing on exposed, slightly raised mounds of coarse sediment that would be subject to great evaporation in between periods of tidal inundation. The photographs above and below, show the typical small mounds of glasswort from a distance and in closeup.

Glasswort is often found growing with sea primrose, remuremu, buck's horn plantain and dwarf cushion sedge in open dry areas of low-growing plants, commonly called salt meadows or salt turfs.

A small patch of salt meadow near dunes

4.8 tall fescue

Scientific name:	*Schedonorus arundinaceus*
Common name:	tall fescue
Family:	**Poaceae**

Tall fescue is a tall, robust, exotic, perennial tussock. Grasses are often difficult to identify, but tall fescue as its name suggests, is large and conspicuous. The tall flower spike may be up to 1.8 m tall and is visible even above the 1.4 m oioi. The leaves are broad and a yellow-green colour. The bases of the leaf sheaths are a reddish colour.

A confirming feature requires carefully running a finger down the midrib on the underside of the leaf. Microscopic teeth make this extremely difficult and possibly hazardous. It is worth doing, but with care, and tall fescue is the only salt marsh grass with such an obvious feature. Being salt tolerant it readily colonises the older areas of salt marsh that have less tidal impact, and where coarser sediments have built up. Typically it is found growing amongst oioi swards, sometimes sea rush clumps, and around the base of marsh ribbonwoods. Small mounds near the sand dunes typically have tall fescue and knobby club rush.

Sometimes areas of salt marsh become cut off from the tidal influence and gradually tall fescue, creeping bent grass and couch grass become more dominant. Sometimes these areas become impounded and swampy with freshwater. Tall fescue, creeping bent and oioi can remain in these conditions, but eventually give way to raupo.

Ponded area with some remaining tall fescue clumps on the right

4.9 marsh ribbonwood

Typically, marsh ribbonwood seedlings germinate amongst clumps of oioi, but may be found as individual bushes out in the open areas of the upper marsh, where there has been some build up of sediment and organic matter. The seedlings are able to germinate and grow in the very shaded habitat of an oioi clump.

Scientific name:	*Plagianthus divaricatus*
Common name:	marsh ribbonwood
Family:	**Malvaceae**

Marsh ribbonwood is the only woody perennial native shrub found growing in any numbers in the Brooklands salt marsh. As its name suggests, the woody stems branch repeatedly to form a dense twiggy bush that can grow to 2.5 m. From a distance the bushes look grey and without leaves, but on closer inspection the dark olive-green narrow 5–15 mm long leaves are obvious. In early summer the numerous, small creamy-white flowers are lined up along the woody stems.

In very old areas of salt marsh, there may be almost total coverage by oioi and marsh ribbonwood. As the ribbonwood bushes grow to 1.8m the oioi stems still poke through the branches, but at 2 metres the marsh ribbonwood seems to completely shade the oioi and it dies. This leaves the marsh ribbonwood as the climax vegetation of the Canterbury salt marshes.

Mature upper marsh fringe in the Styx-Waimakariri region

Dead-looking from a distance

4.10 shore sedge

Scientific name: *Carex litorosa*
Common name: shore sedge
Family: Cyperaceae

Shore sedge is easily recognisable as the only salt marsh species resembling a low-growing tussock. The narrow (<5 mm) leaves are v-shaped but the flowering stem is triangular. Plants are a reddish-brown colour and occur as tufts. During late summer, the colour tends to fade to a pale-straw shade. Although it is listed as a threatened species, it is relatively common in the southern lagoon, particularly on the slightly raised levees (edges of channels). Also occasionally found amongst three square swards in the south spit, middle spit and Brooklands regions.

Shore sedge growing on the edges of the dendritic tidal channels that extend through the salt marsh at Spencerville

4.11 native musk

Scientific name: *Mimulus repens*
Common name: native musk
Family: Scrophulariaceae

Native musk is a native, low-growing semi-succulent creeping herb, with small, rounded, fleshy, deep purple-bronze coloured leaves 3–7 mm in diameter.

The creeping stem spreads out over the waterlogged finer sediments forming large mats of foliage generally <5 cm in height. In January-February the obvious pale lilac-coloured flowers are very attractive. On the threatened species species list, but common in the wetter southern Spencerville and Pikelets regions. Was also found bordering man-made ponds between the stop banks in the Styx-Waimakariri region.

Native musk and turf daisy at Spencerville

Expanse of native musk bordering three square

A mixture of native musk and batchelor's button

Native musk growing at the base of a clump of shore sedge

4.12 salt grass

Scientific name:	*Puccinellia stricta*
Common name:	salt grass
Family:	**Poaceae**

Salt grass is the most common, narrow-bladed, blue-green or slightly yellow-green grass on the salt marsh. It is a native tuft-forming perennial. Identification of this grass can be difficult because of the considerable variation in size. However, other salt grasses are highly restricted, and so on the salt marsh proper, this is the species you are most likely to see. Variations in height, colour and width of leaf blades are common.

A coarser form of salt grass

A distinctive feature that is shared with the Poa genus is the prow-shaped leaf tips that will split if you try to flatten them. The leaf sheath is open, hairless, and a light brownish purple colour.

Often found in isolated clumps colonising open mud flats and sandy tracks especially in the Brooklands and North Spit regions. Also found as small clumps amongst low-growing turfs of remuremu, buck's horn plantain and sparse sea rush.

A small salt grass tuft with sea primrose

4.13 knobby club rush

Scientific name: *Ficinia nodosa*
Common name: knobby club rush
Family: Cyperaceae

Knobby club rush is a native perennial clump-forming sedge, with distinctive yellow-green culms, each being a single shoot from the rhizome, and bearing a tight, spherical cluster of flowers near the tip. Clumps are up to 90 cm high.

It is always found in the upper marsh fringe or on raised edges of old sand dune mounds, more characteristic of the northern part of the lagoon. When growing amongst sea rush, it can generally be distinguished because of its spherical-shaped inflorescence.

Easy to compare sea rush and knobby club rush

Harder to pick the differences

4.14 dwarf cushion sedge

A small sward of dwarf cushion sedge amongst remuremu, sea primrose and buck's horn plantain

Scientific name: Schoenus concinnus
Common name: dwarf cushion sedge
Family: Cyperaceae

Dwarf cushion sedge is a native, low growing, (typically 30–80 mm), sward-forming, perennial sedge with delicate, shiny vivid green wiry leaves (<0.5 mm diameter), and obvious crimson leaf base. The small, dark brown inflorescence is always found approximately 5 mm from the tip of the leaf. Occasionally the tip of the flower stalk is a bright red colour.

It is often found in open upper marsh areas as part of a salt meadow turf with remuremu, glasswort, buck's horn plantain, or nestled amongst the base of upper marsh sea rush with remuremu. Be careful not to confuse it with small salt grass clumps of *Puccinellia stricta* which are distinctly paler in colour.

The three photos at right show detail of new season's growth, a closeup of a typical salt meadow mix of species, and a large patch of North Spit salt meadow

4.15 turf daisy

Scientific name: *Leptinella dioica*
Common name: turf daisy
Family: **Asteraceae**

Turf daisy is a mat-forming, low-growing herb with the distinctive multi-lobed fern-like dark green leaves (15mm x 30 mm) which differ from the smooth margin leaves of remuremu.

Mostly shade-loving and found at the base of sea rush, oioi or marsh ribbonwood clumps, often with native celery or native musk (as below). Most abundant in the southern part of the lagoon, and in the upper marsh along the spit.

4.16 bachelor's button

Scientific name:	*Cotula coronopifolia*
Common name:	bachelor's button
Family:	**Asteraceae**

Bachelor's button is a semi-succulent annual native herb, with characteristic 'antler-like' fleshy-looking, pointed, lobed leaves. Being annual it is very variable in size, but can always be distinguished by the obvious yellow button-like inflorescence it produces throughout the season. Larger plants can often form large patches especially in low-lying, brackish, ponded areas.

Its preference for brackish water results in it being restricted to the southern Spencerville part of the estuary, and man-made ponds in the vicinity of the Styx-Waimakariri stopbanks where tidal waters hardly ever reach.

4.17 yellow lotus

Scientific name: *Lotus tenuis*
Common name: yellow lotus
Family: Fabaceae

Yellow lotus is a scrambling perennial herb distinguished by it clover-like palmately-compound leaves, each made up of three leaflets. It has typical legume five-petalled yellow flowers, and 15 mm long dark brown dry pods.

It is the only legume species found on the salt marsh, and could potentially become invasive in areas that have almost lost the salt water connection. It may be found climbing amongst tall fescue and oioi in drier areas of the upper marsh fringe. It is most abundant all along the spit side of the lagoon and the Brooklands region, but in the disturbed upper fringes of the Styx foreshore it is rampant amongst huge clumps of buck's horn plantain (see the photo bottom right). It is the only nitrogen-fixing species growing on the salt marsh.

4.18 native celery

Scientific name: *Apium prostratum*
Common name: native celery
Family: Apiaceae

Native celery is a small spindly shade-loving herb with pinnately-compound leaves. The parsley-like leaflets each have three pointed lobes. The leaves have a distinctive celery smell when crushed. Although the plant itself is essentially a prostrate rosette, the compound leaves can be up to 30 cm tall often supported by other taller plants

Generally found in the upper marsh around the base of oioi clumps, often with turf daisy, throughout the salt marsh, but never out in the open. The largest plants are in the wetter southern end of the lagoon amongst raupo and tall fescue.

Native celery jumbled in amongst three square

The variable shape of leaflets

Native celery and salt grass (and three square)

4.19 arrow grass

Scientific name: *Triglochin striatum*
Common name: arrow grass
Family: Jungcaginaceae

Arrow grass is a native perennial herb. It has olive green, shiny, incurved chive-like leaves with a distinctive central flower spike which develops clusters of small fruits. Because of its small size and narrow leaves it is easily overlooked.

Most often found amongst three square, but is more obvious when growing above the native musk (*Mimulus repens*). Not common but found in the central part of the Spencerville region and at the northern end of the estuary on the Styx foreshore.

Fruits of arrow grass

Arrow grass growing amongst a mat of native musk

4.20 swamp flax

Scientific name: *Phormium tenax*
Common name: swamp flax, harekeke
Family: Phormiaceae

Slightly stunted and yellower swamp flax amongst oioi and tall fescue at South Spit

Swamp flax is the iconic native wetlands shrub. It can grow to 3m in freshwater wetlands but is usually <1.5m in salt marshes, with the leaves noticeably more yellow than usual.

It is not very salt tolerant, so is restricted to ponded areas in the southern part of the lagoon or the upper marsh fringe growing amongst oioi on the spit. Often the leaves have the characteristic 'windows' and 'notches' caused by noctuid moth caterpillars, and blotchy dark brown spots.

A three metre swamp flax in a freshwater region at Brooklands near the Waimakariri River stop bank

4.21 creeping bent grass

Large sward of creeping bent in the ponded region in the the southern end of the Spencerville region

Scientific name: *Agrostis stolonifera*
Common name: creeping bent
Family: Poaceae

Creeping bent is an exotic perennial trailing grass forming large patches across the surface or occasionally climbing through shrubs. The leaves are relatively narrow (<5 mm), and never > 10 cm long, have no keel, a smooth surface texture and are pointed. Easily confused with couch grass, until examined for the stolons of creeping bent, or the characteristic underground white-pointed rhizomes of couch.

A confirming feature is the presence of a 2–6 mm ligule, easily visible, and complete absence of auricles.

Floating mats of creeping bent often form over the margins of waterlogged or ponded areas with low salinity. It is also found in disturbed areas near the upper marsh fringe often growing near oioi, tall fescue and marsh ribbonwood. As its name suggests, it spreads over the surface of sediments or water with a creeping stem (stolon) sending up erect shoots.

Clumps of creeping bent in a ponded area in the old Waimakariri region that has lost its salt water connection

4.22 sea spurrey

Scientific name: *Spergularia media*
Common name: sea spurrey
Family: Caryophyllaceae

Sea spurrey is an annual, opportunist, succulent plant forming fast-growing but short-lived clumps in spring. The characteristic curved fleshy leaves, that are paired on reddish stems, have distinct white scales at the base.

It is often found colonizing open mudflat areas or the upper marsh fringes on disturbed ground. By producing vast numbers of tiny seeds this plant can appear almost anywhere each year.

4.23 sea blite

Scientific name: *Suaeda novaezelandiae*
Common name: sea blite
Family: Chenopodiaceae

Sea blite is a native perennial much-branched succulent sub-shrub, with slightly woody stems and fleshy keel-shaped leaves resembling a mini-iceplant. Its extreme tolerance to high salinity (> 200% SW) allows it to grow in highly saline dry soils. It may be found at the Brooklands site, where the edge of the salt marsh proper meets the tall pine forest belt, even growing amongst the pine needles.

4.24 orache

Scientific name: *Atriplex prostrata*
Common name: orache
Family: Chenopodiaceae

Orache is a distinctive grey-green upright annual herb with characteristic triangular-shaped leaves that tend to have an obvious red-maroon line around the margin. Close examination will reveal small granule-like structures on the upper surface of the leaves, which are used for salt excretion.

It is normally found in the upper marsh fringe on sandy, slightly disturbed ground in amongst knobby club rush and tall fescue. Being an annual, its appearance in the same location is not always guaranteed, and in autumn all you will see will be the skeletal remains of the stems. Most abundant in the Brooklands region near the edge of the pines.

Orache at Brooklands with sea blite, glasswort and tall fescue

Detail of the characteristic crimson markings on the margin of the leaf (also found on the stem). Note the mealy upper surface to the leaf.

4.25 cord grass

Scientific name: *Spartina anglica*
Common name: cord grass
Family: Poaceae

Cord grass is a super-coloniser of salt marsh mudflats. It is an exotic salt marsh plant that recently resulted from a cross between the British species, *Spartina maritima* and the introduced American species, *Spartina alterniflora*. This hybrid (*Spartina x townsendii*), was initially sterile, but by chance developed a polyploid chromosome doubling to instantly become fertile, thus producing a 'super weed' because of its extraordinary colonising and competitive ability.

Cord grass invasion on the Styx Foreshore

Cord grass invasion on Middle Spit near a mai mai. Sea rush clumps are in the distance, and a sward of three square die back is in the foreground

Cord grass is a C4 plant utilising a more efficient photosynthesis process than its competing normal C3 plants. The only restriction on the growth rate of C4 plants is inability of the sugar transporting phloem tissue being unable to keep up with the extraordinary rate of production. This is not a problem for cord grass as it shuts down photosynthesis twice a day with the tides, and catches up on the transport of sugars to the roots.

It also has an efficient method for removing excess salt, by excreting it onto the upper surface of the leaves for the rain and tide to wash off! Sometimes you can see the salt crystals on the leaves between high tides.

A large patch of cord grass at the Styx River mouth

Cord grass has already established in the north of NZ, but in Canterbury, eradication work begins as soon as a new population is found. The photos above and below, show three of the four patches recently observed at Brooklands Lagoon. If you stumble upon what you think is an outbreak of cord grass, contact Environment Canterbury.

4.26 sand couch

The distinctive rhizome of sand couch

Scientific name: *Thinopyrum juneiforme*
Common name: sand couch
Family: Poaceae

Sand couch is an exotic, sward-forming, perennial grass, very similar in form to the common garden couch with its typical pointed underground rhizome. It can be easily distinguished by its inrolled leaves, bluish-grey colour, and prominently ribbed upper leaf surface. It does have a reddish-maroon, hairless, leaf sheath, but so do a lot of other grasses. The ligule is tiny, and auricles are absent. Young marram grass plants can have similar features, but marram grass has an incredibly long (15–30 mm !!!) and pointed ligule.

With a slight salt tolerance it is normally found colonising the sandy sites such as near the lagoon margin in front of the belt of pine trees in the Brooklands region.

Two photos showing patches of sand couch in the Brooklands region

4.27 sickle grass

Detail of the red leaf bases and the distinctive, curved leaves

Scientific name:	*Parapholis incurva*
Common name:	sickle grass
Family:	Poaceae

Sickle grass is an annual, exotic, spindly-looking grass, recognisable by its distinctive, red-tinged, very narrow (<1 mm) curved leaves, that look sickle-shaped.

The leaf sheath is purplish and the ligule is tiny (<1mm). Fine prickle-like teeth can be felt on the ribs of the leaf blade, and the leaf margins are rough, right to the sharp tip.

As an opportunistic grass with some salt tolerance, it may be found early to mid-summer on the open sand flats in the more northern Brooklands region of the estuary.

Recently germinated sickle grass in a small despression on the edge of a mound of knobby club rush. The other species include remuremu, buck's horn plantain and glasswort

4.28 raupo

Raupo on the edge of a pond in the older Waimakariri region that lost its tidal connection with the construction of the stopbanks in the late 1930s.

Scientific name: *Typha orientalis*
Common name: raupo, bullrush
Family: Typhaceae

Raupo is a tall, native, reed with 20 mm wide, thick and spongy, strap-like leaves. The classic bullrush inflorescence is unmistakeable in late summer. Only summer green, raupo dies back in the winter leaving 1.5–1.8 m dead foliage and a gradually disintegrating inflorescence.

Raupo is not salt tolerant at all, but is a significant coloniser of freshwater ponded areas in the extreme southern end at Spencerville. It is also found around the edge of large freshwater ponds that have formed close to the stop banks, near the Waimakariri River in an older area that has lost its salt water connection.

A winter view of the dead raupo leaves and flower stalks in the ponded region in the extreme southern tip of Brooklands Lagoon

4.29 marram grass

Scientific name: *Ammophila arenaria*
Common name: marram grass
Family: Poaceae

Marram grass is a robust exotic, perennial, dune-binding grass. Easily identified by looking for stiff, hairless, grey-green, tightly inrolled leaves with distinctive ridges on the upper surface. The leaf sheath is hairless, and a brownish-purple colour. Can be confused with sand couch, but is easily distinguished by checking the ligule, which may be 15–30 mm long, and pointed. The dense, fluffy 12–15 cm long inflorescence is also an obvious feature.

Marram grass is not a true salt marsh species, but dominates the neighbouring sand dunes. The occasional plant can establish on drier sandier salt marsh sediments close by. Random sightings can occur anywhere along the salt marsh margin.

An eroding, low, sand dune with marram clumps, in the midst of a salt meadow

4.30 couch grass

Scientific name: *Elymus repens*
Common name: couch grass
Family: **Poaceae**

This is the typical, exotic, perennial couch that most gardeners find causing problems, because of its extensive underground, white, sharply pointed rhizomes. It can form huge patches with a thatch of dead leaves beneath. The leaf blades may be up to 30 cm long, 10 mm wide and on mature leaves, the stomata are generally visible as rows of white dots on the lower surface. In disturbed, upper margin areas of the salt marsh, it can be confused with creeping bent grass, but the ligule is very short (<0.5 mm), and the auricles, in contrast are very long, pointed, and curled around the leaf sheath. There is usually a distinct keel at the base of the leaf.

Couch grass is not salt tolerant, and prefers to grow in drier soils, but has proven to be a rapid coloniser of the disturbed upper marsh fringes.

Apart from the white, fibrous, underground rhizome, the long, curly auricles are the key identifying feature

4.31 glaucous goosefoot

A likely habitat at the end of North Spit

A slightly pinker specimen

Scientific name:	*Chenopodium glaucum*
Common name:	glaucous goosefoot
Family:	**Chenopodiaceae**

Glaucous goosefoot is an annual sprawling native succulent herb, instantly recognizable because, as its name suggests, the leaves closely resemble goose feet. Each leaf is at least 2 mm thick, and lies close to the sand surface, two features which distinguish it from its close relative, orache. The colour of the leaves can vary from pale yellow-green to a greeny-red, and the size of the leaves can vary tremendously. Glaucous means the leaves can have a blue-greyish green, waxy appearance. Only found in small amounts at the top end of the North Spit region on bare sand flats.

4.32 grassy club sedge

Scientific name:	*Bolboschoenus caldwellii*
Common name:	grassy club sedge
Family:	Cyperaceae

Grassy club sedge is a striking, tall (about 80 cm in height), bright lime green, sward-forming native perennial sedge. It tends to form large patches, obvious in summer, but which die back in the winter. Similar to three square, it however, has proper leaves, rather than just a triangular culm, and the flower heads have more than one spikelet. Three square culms typically have only one spikelet.

Not salt tolerant, this is one of several species that indicate a predominantly freshwater marsh system. It found only in the more waterlogged ponded regions of the southern lagoon and Pikelet region.

Grassy club sedge is easily distinguished by its colour during the summer

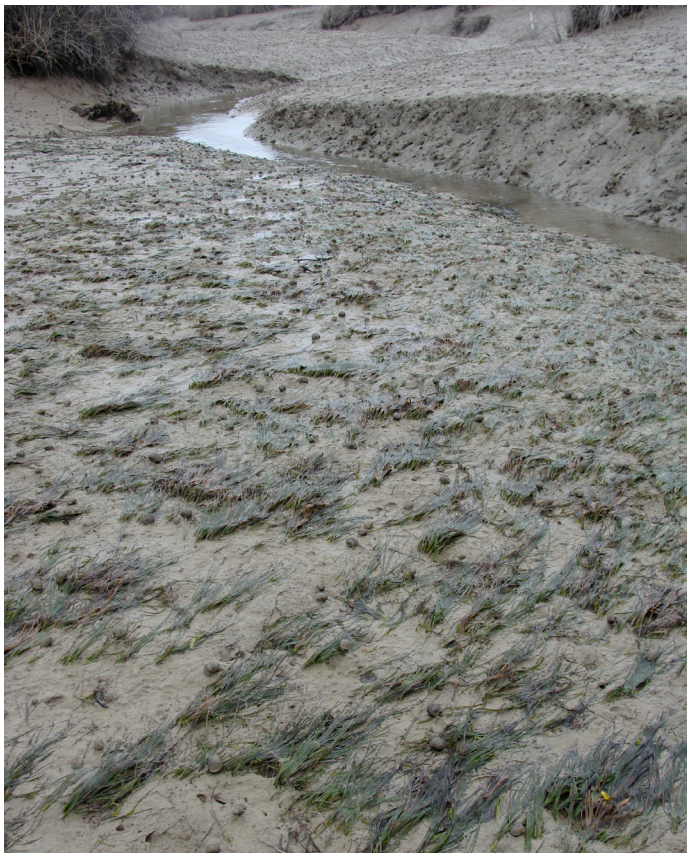
4.33 eel grass

Scientific name: *Zostera capricorni*
Common name: eel grass
Family: Zosteraceae

Eel grass is a native perennial, flattened grass-like marine flowering plant, unusual in that it is always completely covered at high tide. Its very dark brown-green, slimy-looking, narrow (3–4 mm) strap-like leaves lie flush against the mudflats at low tide. The leaves have 4 or 5 parallel veins with variable length cross veins. You could be forgiven for thinking it was a type of seaweed, rather than a plant that has small flowers protected in the leaf sheath, producing tiny fruits and seeds.

Perhaps fortunate to be present in the estuary at all, eel grass is only found in two locations, near a large channel in the Brooklands region and out on the mudflats at the top of the North Spit region. This narrow distribution in a dynamic habitat results in a perilous existence for this special plant.

Distribution of eel grass at the North Spit site



Distribution of eel grass at the Brooklands site

4.34 grass-leaved rush

Scientific name: *Juncus caespiticius*
Common name: grass-leaved rush
Family: Juncaceae

Grass-leaved rush is a small, perennial, tufted rush, with distinct grass-like, v-shaped, in-rolled, bright lime green leaves never more than 15–20 cm long and up to 8 mm wide at the base. The spherical inflorescence protrudes from the slightly longer cylindrical culm or stalk.

This attractive, tiny rush is not common at all in the Brooklands salt marsh, found only in one location on South spit in previously disturbed vehicle tracks in the upper marsh zone.

South Spit vehicle tracks provide the ideal habitat for grass-leaved rush

4.35 Yorkshire fog

Close up photographs showing the hairy, velvety leaves, with a distinct keel and ligule, but no auricles

Scientific name:	*Holcus lanatus*
Common name:	Yorkshire fog
Family:	**Poaceae**

Yorkshire fog is an exotic, tuft-forming perennial grass, easily distinguished from the other grasses by its very soft velvet-feeling, hairy, greyish-green pale leaves. The leaf sheath is also hairy (in contrast to the other grasses found at Brooklands), with reddish-purple veins on a white background, that give it a characteristic 'pyjama stripe'. The white, hairy ligule is 1–4 mm long, and auricles are absent. The leaves have a distinct keel.

In contrast to tall fescue, it has little or no salt tolerance, and would only be found on the dampish fringes of the upper salt marsh, generally amongst couch and creeping bent.

The characteristic red and white 'pyjama stripes' on the base of the leaf sheaths

Appendix

5.1 The importance of osmosis

Osmosis is a passive process dependent on a special structure that surrounds all living cells, the cell membrane. All molecules diffuse, or move by random collisions from a region where they are highly concentrated to a region of lower concentration. This 'spreading out' or diffusing of molecules occurs everywhere, and is largely dependent on the concentration difference. The cell membrane has millions of tiny pores that allow the smaller water molecules to pass through, but prevent the larger sodium and chloride ions (that make up salt molecules) from moving through. The cell membrane is regarded as being selectively permeable because of this. Water molecules however will always diffuse according to the laws of diffusion, and unless there is the same concentration of water molecules on each side of a cell membrane, there will be a net movement of water molecules from one side to the other. This can have the effect of making a cell swell up and become turgid, if it gains water molecules, or collapse in a flaccid state, if there is a loss of water molecules. Plant cells have a special outer covering of cellulose fibres, much like the leather of a football, that prevents the cell from bursting if too much water enters. Human cells are not so lucky, and cells such as red blood cells would swell up and burst if blood plasma did not contain exactly the same concentration of water as the 0.9% salt solution found inside the cells.

A bigger problem for plant roots is if the net movement of water is out of the root cells rather than inwards. This situation occurs if the salt concentration around the root cells is greater than the dilute salt solution found inside the cells. It is easier to think of a dilute salt solution as having a higher water molecule concentration than a more concentrated salt solution. The only way for plant roots in a saline environment to absorb water is to actively transport salt into the root cells and as a result, water molecules diffuse inwards (as the relative concentration of water molecules changes). The problem now is the removal of the excess salt. All successful salt tolerant plants must have a method for removing or storing excess salt. Tall fescue stores the salt in its leaves which eventually die, dry out, and decompose. Orache has special bladder cells on the leaf surface full of salt, which regularly are rubbed off. Cord grass excretes the excess salt directly onto the leaves for the tide and rain to wash off.

5.2 The importance of active transport

All of the water uptake and salt excretion mechanisms of halophytes require a cellular process called active transport. This is a special function of the cell membrane and involves incredible energy-driven proteins that by changing their molecular shape temporarily, they can transport specific molecules in or out of the cell. The energy for this shape transformation comes in the form of the universal energy molecule ATP. Another cell process, cell respiraton, that occurs in all cells of all organisms, produces ATP from some of the glucose produced during photosynthesis. As a result of putting more energy into maintenance processes such as water and salt movement, the plants have less excess energy to devote to growth or reproduction. Active transport is brilliant and necessary, but comes at a cost.

5.3 Investigating the structure of grasses

Grasses seem to be the most difficult plants to identify. Everyone gets tricked by the similar general appearance of grasses. A good way to become more confident identifying grasses is to become familiar with the basic structure common to all grasses, and then spot the slight morphological differences.

The grass leaves and flower stalk grow from a meristem (cell division point) positioned at the base of the plant. Other groups of plants tend to have their growing point at the tips of branches and the base of leaves. This makes them vulnerable to grazing animals, and is the reason why clipping the tips off branches will encourage a hedge form to develop. Grasses grow and elongate at the protected base of the plant, and can thus withstand heavy grazing (and mowing!). Each leaf of a grass

is divided into a leaf sheath and a leaf blade. The leaf sheaths of successive leaves are all concentrically arranged in a central cylinder growing from the basal meristem. The point at which the leaf blade diverges from the leaf sheath is generally marked by a ligule. This ligule is a continuation of the leaf base, and can be viewed by carefully pulling the leaf sheath (and blade) away from the main 'stalk' (of leaf sheaths). The ligule is semi-transparent (not green), and its size, shape and hairiness may be used for identification. e.g. Two grasses found in the upper marsh fringe bordering sand dunes are sand couch and marram grass. Both have rolled leaves with the inner (upper epidermis) surface distinctly ridged. Both can also have maroon-purple leaf sheaths. Mature marram plants are significantly bigger than sand couch, but the young plants are difficult to tell apart. By examining the ligules, you can see that marram grass has huge, pointed ligules ranging from 15–30 mm, but sand couch has ligules no more than 1mm high. Often when separating and unfolding the marram leaf sheaths, the large ligule will tear in two and appear V-shaped.

Ligules sometimes have extensions called auricles, that partially wrap around the stem. The classic example of this is couch grass, which has long curly auricles, instantly visible, and a great help in its identification.

It is a worthwhile exercise to try and remove all the leaves and leaf sheaths one by one to see how each leaf originated from the meristematic base. At the end of the season, the meristem elongates significantly (in the centre of the cylinder of leaf sheaths) and forms a large flower stalk which will bear the inflorescences. The inflorescences are the best feature for identifying grasses, but often the grasses are not at the flowering stage.

The 12 most common salt marsh species found at Brooklands Lagoon

sea rush

Juncus kraussii

three square

Schoenoplectus pungens

oioi

Apodasmia similis

knobby club rush

Ficinia nodosa

remuremu

Selliera radicans

sea primrose

Samolus repens

glasswort

Sarcocornia quinqueflora

buck's horn plantain

Plantago coronopus

marsh ribbonwood

Plagianthus divaricatus

yellow lotus

Lotus tenuis

tall fescue

Schedonorus arundinaceus

shore sedge

Carex litorosa

12 salt marsh species found less commonly at Brooklands Lagoon

native celery

Apium prostratum

turf daisy

Leptinella dioica

native musk

Mimulus repens

orache

Atriplex prostrata

salt grass

Puccinellia stricta

dwarf cushion sedge

Schoenus concinnus

sand couch

Thinopyrum junceiforme

raupo

Typha orientalis

arrow grass

Triglochin striatum

sea spurrey

Spergularia media

bachelor's button

Cotula coronopifolia

creeping bent grass

Agrostis stolonifera