NIWA
Taihoro Nukurangi

NATIVE SALTWATER PLANT CULTIVATION

Guidance on the nursery cultivation and restoration of native submerged plants in coastal lakes, lagoons and estuaries

CONTENTS

Front cover: Flowering stem of *Samolus repens*.

This page: Underwater view of *Ruppia*.

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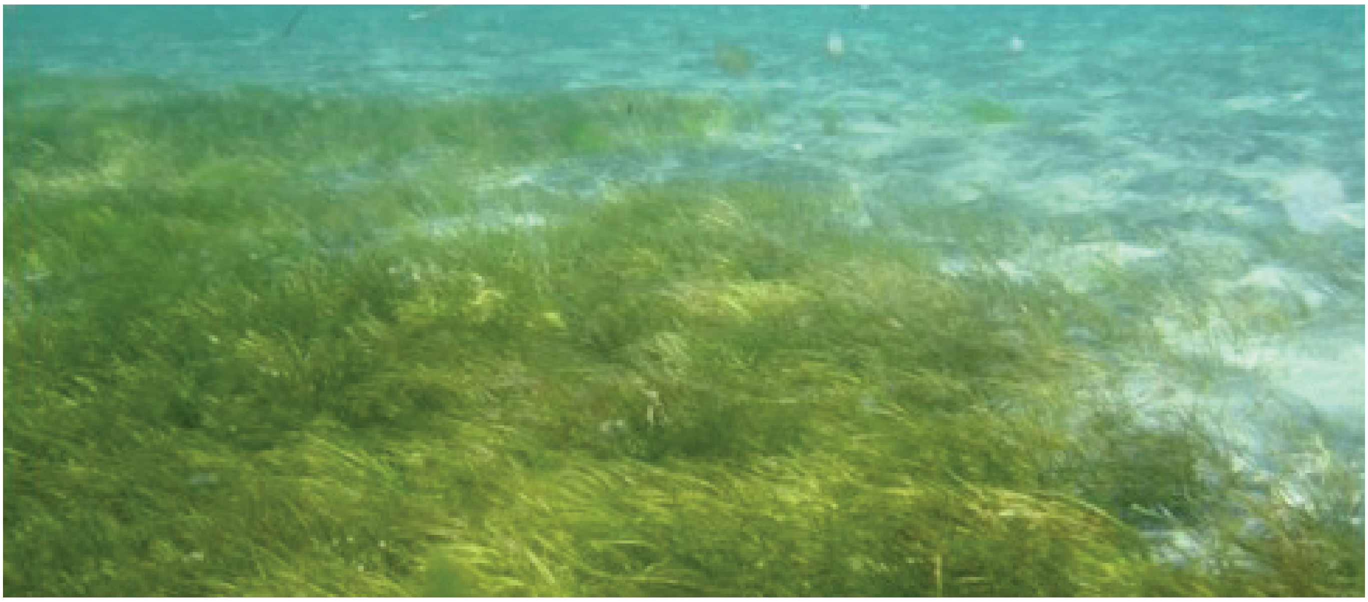


Underwater bed of seagrass.

WHAT ARE MACROPHYTES AND WHERE ARE THEY FOUND?

Macrophytes are aquatic plants large enough to see with the naked eye, growing in freshwater, brackish and saltwater waterbodies.

A companion booklet covers freshwater species.

WHY ARE AQUATIC PLANTS IMPORTANT?

Aquatic plants are important because they support ecosystem processes such as primary productivity, nutrient sequestration, sediment aeration and stability and the provision of habitat for aquatic animals. This publication focuses on submerged aquatic plants – those that grow mostly beneath the water surface.

PURPOSE OF THIS PUBLICATION

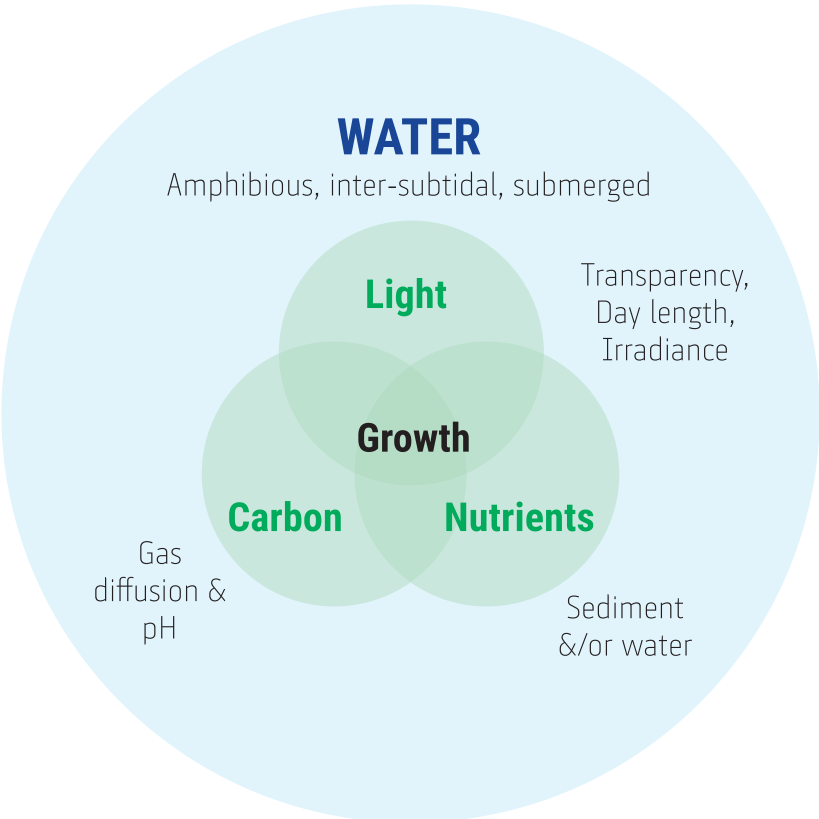
The purpose of this booklet is to help provide guidance on the cultivation and restoration of native submerged macrophytes for environmental rehabilitation initiatives in brackish and saltwater.

WHAT DO SUBMERGED AQUATIC PLANTS REQUIRE?

Submerged aquatic plants require immersion in water for long-term survival, but some life-forms (e.g., amphibious plants) have different tolerances to emersion.

Three key factors are needed to support aquatic plant growth:

- **Light** is essential and is strongly influenced by water transparency, but also by fouling of plant surfaces and shading by other plants and algae. Light needs to reach plant leaves in order for photosynthesis and growth to occur.
- **Carbon** must be available as dissolved carbon dioxide or bicarbonate depending on water pH. Carbon is needed for growth and can sometimes be limiting, especially in still waterbodies.
- **Nutrients** and trace elements are required and are accessed by submerged plants from the water or sediments. Favoured sediments are usually fine sands and silts, providing a stable, penetrable rooting medium and a nutrient supply.



Key factors for submerged macrophyte growth

Example of a culture facility.

CULTIVATION OF AQUATIC PLANTS

Culture facility / tanks. Culture environments are based on tanks, shallow ponds or flowways lined to retain water. Water needs to be of a depth sufficient for the macrophyte species. For example, species commonly growing over 1 m will need a water depth of about 1.5 m, while low growing species (<0.2 m) can be cultured in shallow water of about 0.3 m.

Water source. Submerged macrophytes require immersion in water for long-term survival. An adequate clean water source (ideally free from chlorine) is needed to allow for filling and potential flushing of culture tanks. Chlorinated water can have a negative impact (cause bleaching or even death) of aquatic plants.

Salinity. There may be a need to acclimate cultivated plants to similar salinity levels expected in the brackish or saltwater systems where they will eventually be planted. Salinity in brackish environments is frequently in the range of 2 to 10 PSU. Seawater has an average PSU of 35.5. Adjusting salinity can be achieved by adding natural salt (i.e., evaporated sea salt) in batches to raise the salinity by 1 to 2 PSU every week or two until the target salinity is achieved.

Shade cloth used to reduce the light level in the culture tank.

Cultivation of aquatic plants continued

Light. Natural light is best but artificial lighting can also be used. Plants use photosynthetically available radiation (PAR) in wavelengths 400 to 700 nm. Lighting that provides submerged plants with PAR of more than 10 mol m^{-2} d^{-1} is recommended. PAR can be measured with a special measuring instrument (i.e., a quantum sensor). Shade cloth can be used to limit algal growth, if this is an issue, but low light may also constrain plant growth requiring more time to reach the target size.

Nutrients. Using water that is generally low in nutrients (e.g. tap water) can help to avoid algal growth. If nutrients in water are relied upon to support plant growth then at least 0.1 mg/L of phosphorous (P) and 1 mg/L of nitrogen (N) is recommended. Alternatively, low nutrient water can be used in combination with a substrate nutrient supply (see below).

Substrates. Suitable substrates include fine-textured soils or sediments with a low to moderate organic content (up to 20 %). Substrate sources could either be a donor sediment from an aquatic site that supports macrophytes, the recipient environment (substrate from the area you are going to plant e.g., for testing suitability) or commercially available products. Screened topsoil modified with washed sand in about a 50:50 mix can work well. Slow-release fertilizer may be added for prolonged culture periods (>2 months). Potting mixes that contain wood chip, peat, vermiculite or perlite are generally unsuitable as they initially float and dirty the water. A 3 to 5 cm cap of washed sand over the surface of the substrate helps to retain nutrients and prevent suspension of fine particles.

Temperature. Water temperature can influence the rate (speed) of plant growth but is likely to be less important than daylength and light availability. Natural light availability varies seasonally with day length, being less in winter, and more in summer. Optimal water temperatures for growth are usually in the range from 15 to 25°C.

Culturing macrophytes in pots, grouped on a tray for ease of handling.

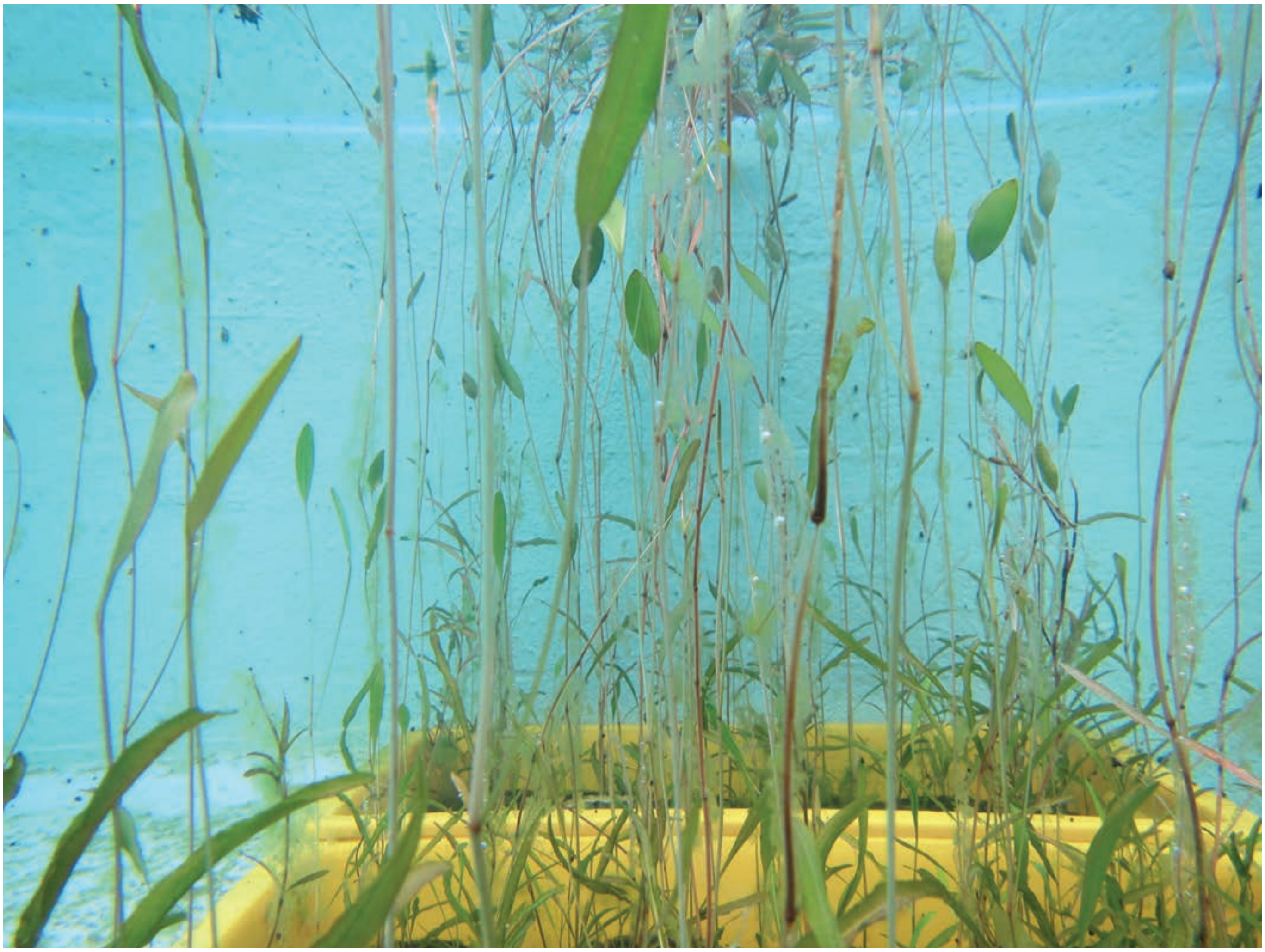
Plant pots

Submerged macrophytes can be difficult to repot so in some cases it may be best to grow the plants directly in the container for transplanting. Containers should be of a size adequate for the macrophyte species and for handling. Also, because retrieving and depositing containers from tanks can be difficult, it is helpful to group them on trays (e.g., nursery shuttle trays) with a means of retrieval (e.g., handles, strings (example above)).

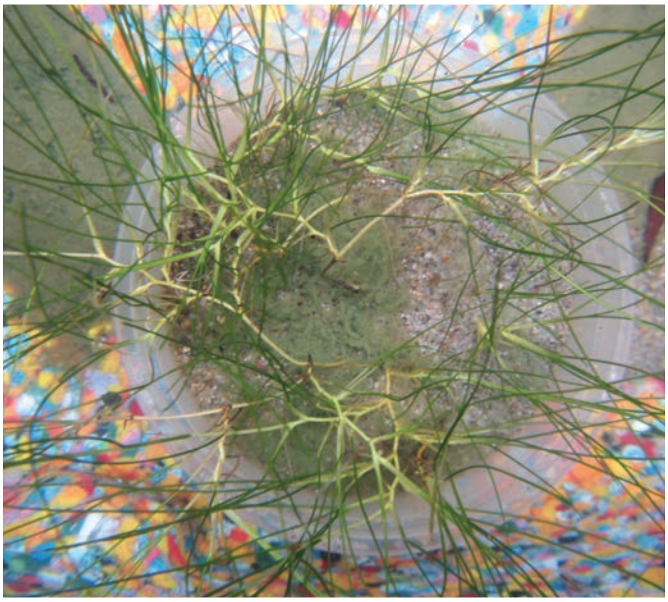
Plastic nursery pots or trays are suitable for macrophyte culture, but thought needs to be given to transferring the rooted plant during transplantation. For example, cotton, hessian or coconut fibre liners could be used in trays for transplanting macrophytes. Suitable compostable pots are available in the form of wood chip (e.g., Fertilpots), peat or coconut-coir fibre (see image below).

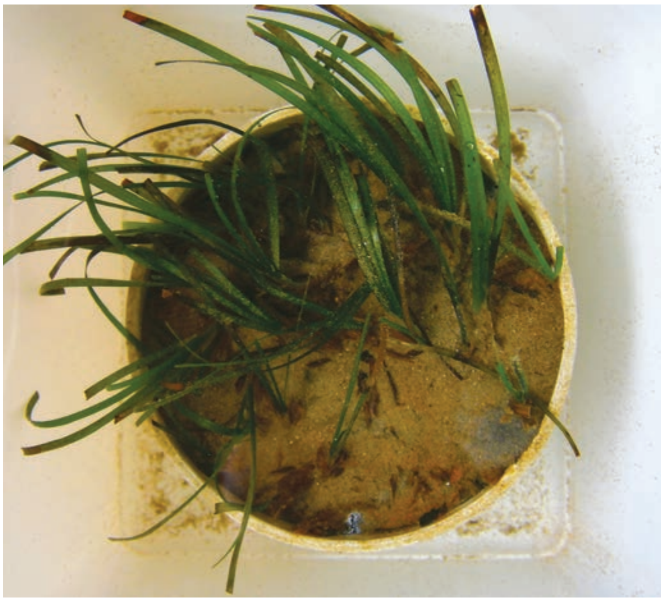
Note some compostable pots (e.g., bamboo) require specific conditions for breakdown, and others may release tannins in the water and initially reduce water clarity. It may be possible to reduce staining by pre-soaking pots.

Using compostable materials in culturing macrophytes will allow direct transplanting without disturbance of root systems.



Trays of native plants in cultivation.





Native plants grown in smaller pots.

Cultivation of aquatic plants continued

Plant propagules – seeds or vegetative propagules

Seeds can be obtained from the sediments of waterbody margins (the shallows) and can be concentrated (removed) from the sediment by sieving.

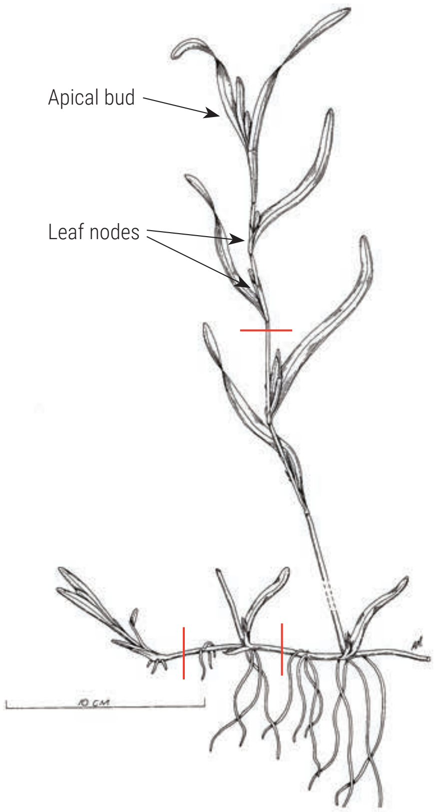
Sieve aperture (hole) sizes need to match the size of the seed sought (e.g., with aperture in the range of 250 to 500 µm for charophyte oospores and c. 700 µm sufficient for seed of most vascular species).

Sieved material can be spread on top of substrate and covered with a thin layer of washed sand in shallow trays. These should be placed for germination with 0.2 to 0.3 m water depth under 30 to 50% sunlight levels and warm temperatures (15 to 20°C).

Germination of most species occurs in a few weeks, but for some seed, germination can be enhanced by a preceding period of cool storage (4°C) or darkness.

Submerged macrophytes generally propagate well from vegetative fragments. Vegetative propagules may be a shoot section or horizontal rhizome that includes several upright shoots, or entire small plants. Best results are obtained if the apices are intact (apical bud) and there are numerous leaf nodes (axillary buds) on the stem from which roots or additional branches can develop.

Shoot sections should be inserted 5 to 10 cm deep in the substrate to encourage rooting and secured in the substrate with a little pressure. For propagation of the seagrass *Zostera muelleri* from vegetative fragments entire plants will be needed which includes the rhizome and root system.



This plant could easily be divided (cut) where the red lines indicate to create four new individual plants.

Production timeframes

The production schedule for macrophyte culture, is informed by the timing of the planned restoration and the required development of macrophyte root and shoot systems. For instance, a long culture period may be required for material destined for high energy environments (i.e., waves, flowing water) that will need more substantial root anchorage, or where taller material is needed to 'escape' light limitation if this is likely to occur close to the sea, lagoon or lake bed. Note that plants may not be able to tolerate water current speeds >1 m per second.

Growth rates for native New Zealand submerged macrophytes will vary depending on the availability of the key factors required to support growth (see page 4). However, usually a minimum of two to three months should be used for planning to produce suitable transplants for translocation.

SUITABLE SPECIES

A resource to support the collection of suitable species and as a high-level guide to the conditions required for culture.

Seven easy to cultivate species are illustrated in this booklet for brackish and saltwater habitats.

Ruppia megacarpa

Brackish water. Submerged only.

Rhizomes, shoots long often branching in zig-zag pattern, leaf indented at the tip (compared with *Ruppia polycarpa* which is rounded at the tip), seeds 4-6 per head, 4-5 mm long.

Ruppia polycarpa

Brackish/freshwater. Submerged only.

Rhizomes, shoots usually short statured and mostly unbranched unless fruiting, seeds 5-16 per head, <3 mm long.

Zannichellia palustris

Brackish. Submerged only.

Rhizomes, leaves produced in small bunches, leaves taper to a point, 2 to 4 'horned' seeds are at the base of leaf axils.

Althenia bilocularis

Brackish. Submerged only.

Shoots from rhizomes, flat ribbon leaves, alternate in same plane, hydrophobic, leaf tip blunt or 3-toothed.

Samolus repens **(mākoako, raupatariki)**

Brackish. Amphibious.

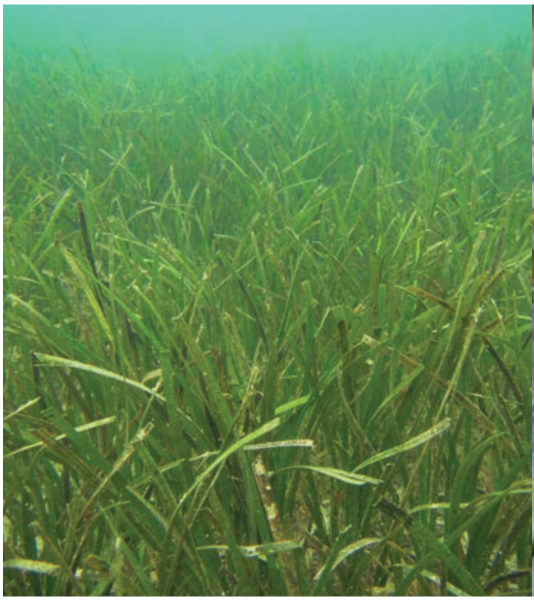
Sprawling, with fleshy spoon-shaped leaves up to 15 mm long alternating along the stem, white star-like flowers.

Lilaeopsis novae-zelandiae

Brackish. Amphibious.

Leaves basal from rhizome, with a series of distinct lines across their length (like a ladder), and the leaves are flattened with obtuse tip.

SUITABLE SPECIES continued




***Zostera muelleri* (karepō, nana, rehia, rimurehia)**

Estuarine. Intertidal/subtidal.

Creeping rhizomes, strap like leaves, with rounded leaf tips. The leaves are up to 30 cm long and 0.5 cm wide when growing subtidally, usually much less on intertidal plants. Separate male and female flowers occur together as an inflorescence enclosed in a spathe borne on a special flowering shoot. One ellipsoid seed 1.7 to 2.4 mm long is produced per female flower ripening over a two-month period. Flowering occurs between September and May, with fruiting to produce seed usually in January-February.

Z. muelleri is New Zealand's only species of seagrass. It is classified as "At risk – declining" by the Department of Conservation.

Sieving for seeds of Ruppia.

SOURCING MACROPHYTES FOR CULTURE

Sourcing and collecting macrophytes should consider:

- plant availability and potential importance of eco-source principles,
- the ability of the source environment to sustain collection,
- biosecurity considerations, and
- regulatory requirements or permissions.

Some native brackish-water submerged species may be found in the aquarium and pond plant trade (e.g., *Samolus repens*) and these could be sources for culture.

Record keeping on the plant collection sources can be useful for future decision-making (e.g., suitability and performance of sourced material).

For sustainable collection ideally no more than 10% of the plants present in the targeted harvest area should be removed unless appropriate controls are in place (for example, careful monitoring of donor population recovery). Harvesting should not be from a locality that might be critical for population recovery. If there are concerns about the sustainability of wild harvesting of whole plants, then seed or limited propagules could be sourced and further propagated under culture.

Donor seagrass meadow being monitored for recovery after propagule collection.

ECO-SOURCE PRINCIPLES

Eco-sourcing for restoration, generally means collecting from the local area, or same region as the site where the plants will be eventually planted.

Local collection of plant materials considers both local adaptation and the likely genetic relatedness of populations of plants and is recommended wherever possible.

BIOSECURITY

Biosecurity and nuisance pests developing under culture conditions or being transferred by direct translocation should be considered. Any risk of spreading pest plants or fish should be minimised by identifying plants carefully and minimising unintentional transfer of water or sediment between the source and the eventual recipient environments. It may be necessary to decontaminate wild collected plants so as to remove hitch-hiking algae, insects or snails that may otherwise proliferate under culture conditions. Any algal material or animals that can be seen should be removed and plants rinsed vigorously under running water.

Prepare a solution of 1-part unscented bleach in 20 parts of water, adding bleach to the water and using gloves for protection. Soak times in the bleach solution for plants should be 90 seconds for delicate plants, 120 seconds for average plants, and up to 150 seconds for hardy plants. Immediately rinse under running water for at least 1 minute. Although it is impossible to provide algal free culture conditions, initial precautions do help.

Identifying amphibious turf plants on an emersed lake shore.

COLLECTION OF PLANTS FOR CULTIVATION

Permissions and/or approvals* need to be sought for both the collection and the translocation of submerged macrophytes where they apply. No regulations apply to their maintenance in culture. Of prime importance is that there is support for the intended restoration and appropriate involvement of iwi, hapū and whānau and other parties with authority and interests in the collection and recipient sites, for example councils. Status of these sites (i.e., ownership, designations, status) will guide this approval and consultation process.

*For example: Collection of aquatic life for research purposes requires a fisheries special permit *(How to apply for a fisheries special permit | MPI | NZ Government).*
Permits for collection of aquatic plant samples from public conservation land (e.g., National Parks, reserves) are required from DOC *(https://www.doc.govt.nz/get-involved/apply-for-permits/research-and-collection/)*.
The Aquatic Life Transfers Standard Operating Procedure (SOP) provided by Department of Conservation sets out the process for applications to transfer and release live aquatic life to freshwater under several pieces of legislation. Special considerations apply to national parks, plants with protected status, and possibly other Acts according to s26ZM(3)(a) Conservation Act 1987 *(Conservation Act 1987 No 65 (as at 07 August 2020), Public Act – New Zealand Legislation)*.
For the movement or release of marine species to the marine environment, instruction is to contact Fisheries New Zealand (MPI) on *fishtransfer@mpi.govt.nz*.

Seagrass transplanted in cores that has spread over time to form larger patches.

TRANSPLANTATION

Transport of submerged macrophytes to the recipient site requires ways to prevent their desiccation, for instance, by covering or spraying with water or using lightweight coverings that are maintained wet.

Key considerations for the recipient site include:

- that growing conditions match the known requirements of the plants as far as possible (see page 4),
- timing of transplantation such as a window of better water clarity,
- water level,
- flow conditions,
- season – the end of winter or early spring is usually best for brackish species, while intertidal seagrass has been successfully transplanted in autumn and winter in New Zealand,
- safe sites i.e., out of high energy wave wash zone if possible, and protection from grazers if necessary.

TRANSPLANTING TECHNIQUES

Several different techniques may be used depending on the constraints of the recipient site.

For example direct transplant of intact plants without sediment (as sprigs) and with sediment (e.g. in cores) has been used successfully for seagrass (*Z. muelleri*) in harbours.

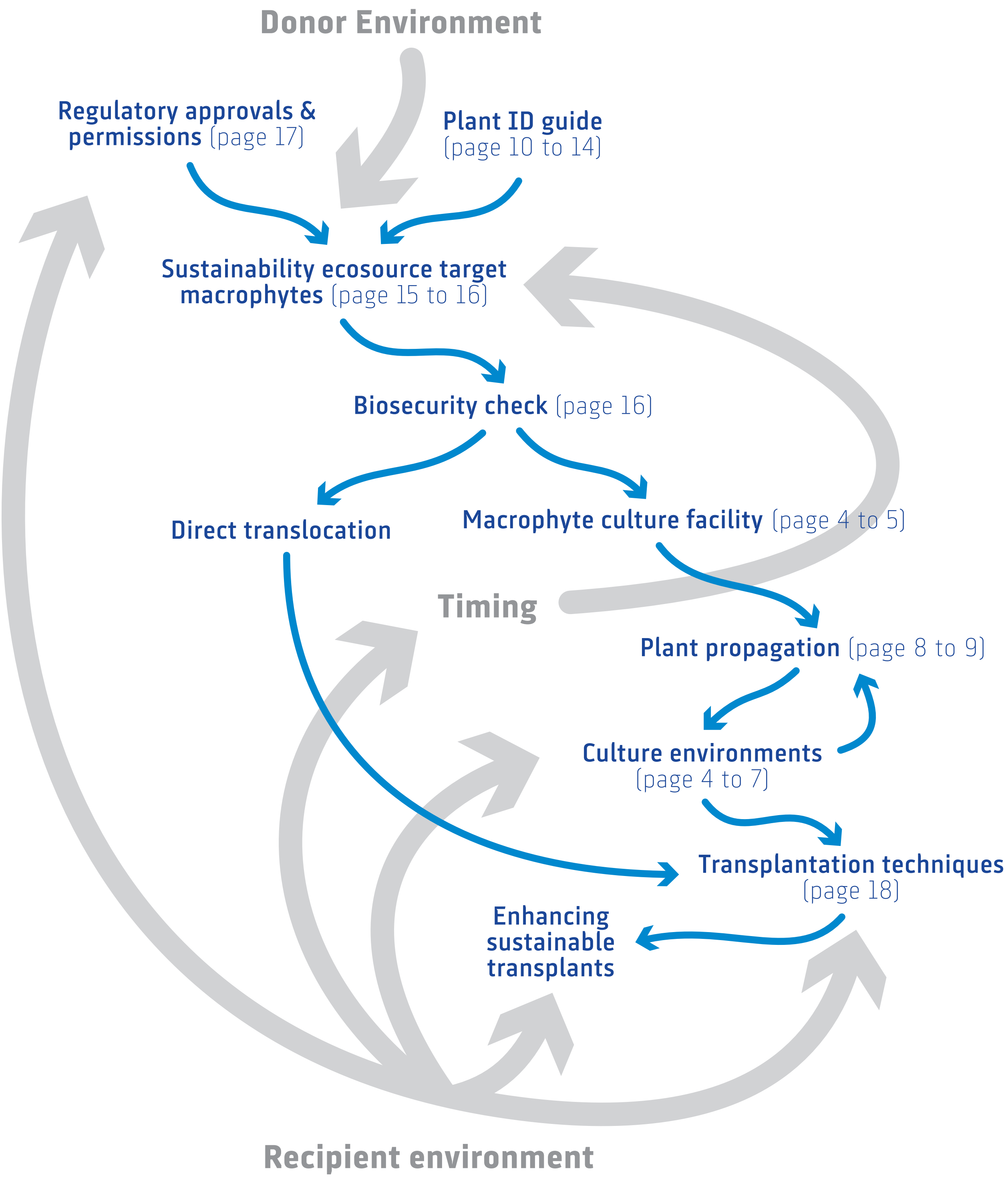
Ruppia plants were pre-cultivated in biodegradable pots in tanks, and then planted by divers in pre-dug holes in the firm sediments of Te Waihora (Lake Ellesmere).

Transplanting seagrass intact plants (sprigs).

IMPLEMENTATION

Flow diagram for major steps in macrophyte rehabilitation.

Blue text and arrows are main action steps, grey text and arrows represent feedbacks determining the nature of key steps or decisions.



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For more visit
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