Riparian Zone Management

Planting Guide

Table of Contents – Planting Guide

Table of Figures

Table of Tables

Planting Guide

The Auckland Regional Council (ARC) has prepared a *Strategy* and *Guideline* for riparian zone management in the Auckland Region. The overall objective of the *Strategy* and *Guideline* is to protect, enhance or restore a sustainable riparian zone. This *Planting Guide* can be used by itself, but it is designed to accompany the *Strategy* and *Guideline*.

The *Strategy* contains the reasons for riparian management, a summary of the scientific literature, the regulatory environment and the natural resources of the region. The *Strategy* identifies the target group as individual landowners, Territorial Authorities, developers, professionals, community groups and Iwi. The mechanism for implementation can be voluntary or mandatory. The ARC has commissioned a Training Manual and will provide training to interested parties.

The *Guideline* describes how to plan and prepare a riparian zone management plan for the individual landowner as well as groups of landowners and more complex programmes. There are a number of case studies in the *Guideline* and a set of field sheets to assist with the collection of data, planning and implementation of the riparian programme.

This *Planting Guide* links into the riparian *Guideline*. Together they provide the process and detail of how to implement a riparian programme. The *Planting Guide* aims to provide simple planting solutions that can be used to establish native vegetation on a broad range of sites. It uses a limited number of highly successfully species that will easily and rapidly establish in riparian plantings.

The *Planting Guide* is divided into two sections:

1. How to carry out a planting project – this section covers the general procedures and principles that will apply for all riparian plantings within the region, such as ecosourcing, managing weeds, and the planting project timetable.
2. What to plant and where – this section provides detailed planting schemes for different parts of the stream bank and the broad range of substrates. It includes specific information on what species to plant and where on the stream bank they should be planted. It deals with how to integrate plantings into the existing vegetation that is to be retained. It also covers the ways to address particular resource management problems using plantings.

When planning a planting, the process outlined in section 2 of the *Guideline* should be followed, using the appropriate *Guideline* Field Sheets. In summary this involves determining:

1. Who owns the land?
2. What's there?
   (Field Sheets 1 to 5)
3. What's the problem?
   (Use the first three columns of Field Sheet 6.)
4. Who else is involved?
5. What do you want to achieve?
   Identifying risks and benefits. Use Field Sheet 7 and the last two columns in Field Sheet 6.
6. What will you plant and where?
7. When and how will you plant?
8. How well is it coming along?
9. Monitoring and review

The *Planting Guide* provides the answers to 'When and how will you plant?' and 'What will you plant and where?'.

Everyone planning a planting will need to read the first section of the *Planting Guide.* This section provides general information applying to all riparian plantings. However, you will use different parts of the second section of the *Planting Guide* depending upon the various answers you have obtained to the *Guideline* questions 'What's there?' and 'What's the problem?'. The following sections will help you to distinguish which parts of the *Planting Guide* are relevant to your project

Whats there? – Vegetation

(Field sheet 3 – Assessing existing riparian vegetation)

Your answer in the Field sheet	Look at Planting Guide section	Planting type
1. Native bush	–	No revegetation required
2. Native shrubland	–	No revegetation required
3. Native tree land	2.4.1	enhancement planting type A
4. Exotic tree land	2.4.2	enhancement planting type B
5. Exotic/native mix	2.4.1 (mainly native) or 2.4.2 (mainly exotic)	enhancement planting type A or B
6. Exotic weeds	2.3	normal revegetation
7. Pasture	2.3	normal revegetation
8. Cropland	2.3	normal revegetation
9. Display gardens	2.4.3	enhancement planting type C
10. No riparian vegetation	2.3	normal revegetation

Whats there? – Geology

(Field sheet 1 – Categories of Auckland Streams)

Your answer in the Field Sheet	Look at Planting Guide Section		
Catchment Geology and Soil Types	**For required background reading**	**For probable planting units**	**For possible planting units**
A. Sandy soils	2.1, 2.2, 2.3 (introduction)	2.3.7, 2.3.8	
B. Alluvial soils	2.1, 2.2, 2.3 (introduction)	2.3.1, 2.3.5	2.3.2, 2.3.3
C Clay soils	2.1, 2.2, 2.3 (introduction)	2.3.1, 2.3.4	2.3.2, 2.3.3
D. Volcanic soils	2.1, 2.2, 2.3 (introduction)	2.3.1, 2.3.3, 2.3.6	2.3.2

What's the problem? – Resource management problems

(Field sheet 6 – Assessment of stream, riparian and terrestrial problems)

Your answer in the Field sheet	Look at Planting Guide section	Planting design requirements
High contaminant inputs	2.5.4	Include consideration of runoff filtering when designing planting
Nutrient enrichment	2.5.4	Include consideration of runoff filtering when designing planting
Lack of shade	2.5.1	Consider plant height, foliage density and the requirements for light and views for those living near the site.
High summer water temperatures	2.5.1	Consider plant height, foliage density and the requirements for light and views for those living near the site.
Inadequate or inappropriate carbon inputs	*2.3.	Any increase in the mass of plant material by a stream will increase carbon inputs. Particularly valuable is soft foliage for nutrition and woody debris for habitat.
Severe flood flow	*2.3. & 2.5.2	Flood water movement is considered throughout the planting designs (*2.3). Trees that block flow, particularly willows, should be removed (2.5.2).
Poor bank-side stability	*2.3 & 2.5.3	Stabilisation of banks is considered throughout the planting designs (*2.3). For banks where erosion is more severe, use bank stabilisation species (2.5.3).
Extent and health of existing native vegetation	*2.3 & 2.4.1	For adding to extent, look at appropriate normal planting sections (*2.3). For health of existing native vegetation, look at enhancement planting (2.4.1)
Extent and health of existing exotic vegetation	*2.3, 1.2, 2.4.2	Where weeds need to be removed, look at weed control (1.2) and appropriate normal planting sections (*2.3). Where weed trees can remain, look at enhancement planting (2.4.2).
Extent of ecological corridors	*2.3 & 1.1	Select your site section (1.1.1) discusses connection and fragment size. Then consult appropriate normal planting sections (*2.3)

* Section 2.3 includes details on the properties of all nine planting units, when referenced above go to 2.3.1 -9 for relevant information.

1.0 Planning a Planting

This section covers the general planting procedures and principles that will apply in all situations within the region. It includes basic planting methods and timetable, managing weeds and ecosourcing your plants.

1.1 Planting Process and Timetable

A sequence of actions needs to be carried out at particular times in order to ensure a planting project is successful. The site needs to be prepared properly and the plants need to be put into the ground at a time of year when they are able to get maximum root growth before the weather becomes hotter and drier and the soils start to dry out. The planted site needs to be managed over subsequent years to enable the planted native species to overcome the first competition from environmental weeds. Good weed management in the first few years of a planting project, combined with a planting designed to rapidly establish a closed canopy, is an essential ingredient for a successful project.

1.1.1 Select your site

The planting site could be selected for a wide variety of reasons. Field Sheet 6 in the *Guideline* will have helped you identify if any of the potential resource management problems are serious. If so, then concentrate efforts along the stretch of stream where the benefits of the new vegetation will be the greatest. Ideally, the planting site should connect existing areas of vegetation to one another. Habitat qualities for both native plants and animals improve as the habitat becomes larger and less fragmented. Carrying out a revegetation that joins two existing habitats will be more valuable in habitat terms than producing a similar area of new vegetation in isolation.

1.1.2 Riparian width

The width of the planting needs to be selected. A 10m minimum width is required to prevent the planting degenerating readily to a weedy strip. However, the planted area should ideally extend to the top of the steep stream bank to achieve better stability (see Strategy section 2.3).

1.1.3 Identify the planting units

Well defined areas of the various planting units need to be identified. Correct identification of the planting units will ensure that the correct species are planted. Accurately defining the actual areas will assist with the programming of work and will ensure that plant supplies, weed and pest control, labour and finances can be forecasted to ensure the project is manageable. It also provides project stages, which help to give people a sense of achievement.

1.1.4 Preparation

Successful plantings require good site preparation. Native plants grow best with low disturbance from pests and stock. Stock need to be excluded from the planting site and waterways, with alternative water sources being provided (see Strategy section 2.5). Pests, such as rabbits, goats, and possums need to be controlled.

Competition for light, water, and nutrients from other plants should be reduced. If plants are covered over by weeds they are unable to get enough light to grow and will eventually die. Invasive environmental weeds need to be eradicated. Grass cover should also be eliminated. The dense root mat, competes strongly with planted natives for water and nutrients and will slow their growth. Competitive weeds need to be reduced in numbers or bulk by mowing or spraying. If possible, broadleaf weeds, such as dock or inkweed, should be encouraged to replace grass weeds, such as kikuyu. This is because the broadleaf weeds provide a degree of shading to the soil surface, but do not have such a strongly competitive root system as the grasses. This initial weed control will prevent the young native plants planted in the area from being immediately out-competed by weeds. Weeds are considered in greater detail in section 1.2.

1.1.5 Planting

Young vegetation will need to be made up of different species than those in nearby mature vegetation. Planting should instead establish a suitable pattern of pioneer vegetation. The soil in open areas along stream banks gets much hotter and drier than that shaded by shrubs and trees. Some species specialise in growing in these situations. Pioneer species are those able to grow first at a site. They are able to cope with the drier hotter conditions in open areas. These species should make up the bulk of a planting in an open area. The majority of plants used need to be able to serve as a nurse crop, sheltering beneath them other species that will establish naturally in the vegetation or will be planted later to encourage forest diversity.

The plants need to be selected and spaced in order to establish a closed canopy as quickly as possible. The closer together plants are placed, the more rapidly a closed canopy will develop. Small plants should be placed closer together, approximately 50cm apart, while larger plants may be placed 70cm to 100cm apart. In some planting units, some of the tree species typical of mature vegetation are able to be planted at this early stage. These are noted in the planting unit species tables in part 2 of this *Planting Guide.*

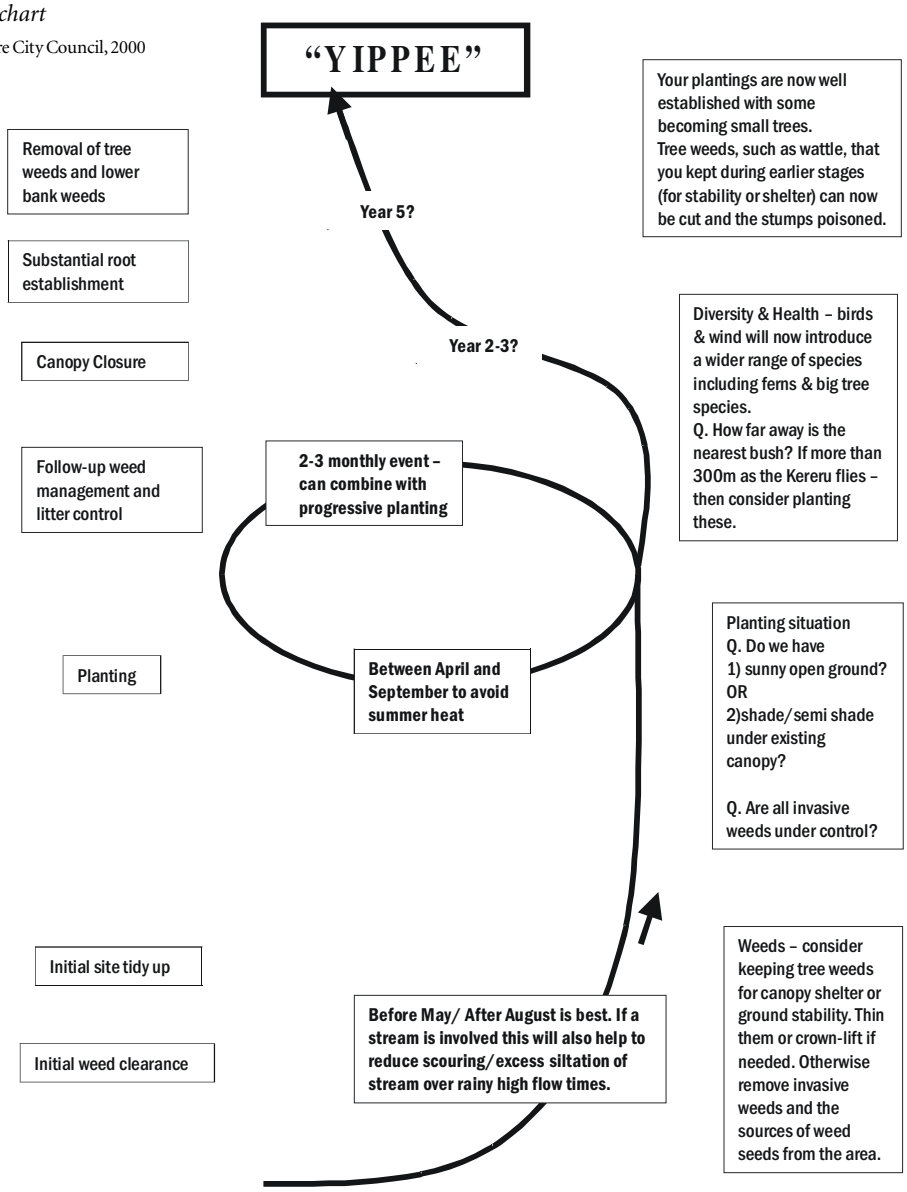
Fertiliser can be used. However, the fertile soils of the lowland stream banks are likely to contain sufficient nutrients for the recommended native species. If mulch is used, then fertiliser should be added to the soil to ensure that the planted natives can obtain sufficient nitrogen over the period of the breakdown of the mulch.

Mulch can be spread over the surface of the damp soils around newly planted natives. Mulch can be matting products or loose material, such as untreated bark or sawdust, that allows water to penetrate to the soil surface. It helps reduce reinvasion by weeds, by burying existing weed seeds and sprouts and by providing a layer that cannot be colonised by most weed seeds.

Stakes should be placed next to each plant as the young natives quickly become very difficult to see as weeds grow up around them. This helps relocate the planted natives during each weeding session.

Figure 1 Revegetation work flowchart

Source Chris Ferkins, Waitakere City Council, 2000



1.1.6 On-going weed control

For the first few years, until a closed canopy is established, relatively intensive weed control will be needed to prevent the young plants being overgrown and shaded out. Competitive weeds should not be removed. Rather they should be kept below the level of the establishing native plants. Weed control will need to continue for more years where small plants are used or where plants are placed further apart.

The stake placed next to each native when it was planted will help them to be found when weed control is being carried out at the site.

1.1.7 Forest diversity planting

In those sites where the eventual cover is intended to be forest, further planting can be carried out when the pioneer cover of the site has established successfully. The species planted in these later planting are those that require damper more shady conditions to establish. The species growing in mature forests in similar positions on similar substrates indicate the sorts of species that should be planted at this stage. These plantings will help make the forest into a more diverse and natural ecosystem.

The accompanying flowchart, reproduced with the permission of Waitakere City Council, shows the necessary timing of the actions that follow site selection.

1.2 Weeds

1.2.1 The problem

Weeds are usually the major problem in a stream bank planting project. Any native plants in a revegetation site along any stream in the Auckland Region will be outcompeted by weeds if some level of regular weed control is not undertaken for the first two to three years. In a planting of well-selected, rapid-growing, closely planted native plants, two to three years is long enough to achieve a continuous canopy that will keep out many of the weeds. Please note that it is pointless to plant, if there are no resources for controlling weeds.

1.2.2 Mulching

Mulching is one method of reducing reinvasion by weeds. When spread around the bases of newly planted natives, mulch prevents the soil from drying out, buries existing weeds and forms an inhospitable surface for colonisation by new weeds. It is usually loose material that allows water to penetrate to the soil surface, but slows down the loss of moisture from the soil. Just about any plant material can be used as mulch, such as bark, untreated sawdust, or chipped prunings. Weeds should not be used as mulch unless you are sure the material is not going to resprout and create a major ongoing weed problem. Grass killed by spraying can be left as mulch. Other materials used as mulch include wet newspapers and old carpet. Commercial mulching fabrics such as weedmat are also available.

A nitrogenous fertiliser will be required on sites where mulch is used. As mulch breaks down, the fungi and bacteria that are decomposing the mulch material will have first call on the available nitrogen in the soil and will leave the plant short of nutrients. The fertiliser should be added to the soil when the plant is being planted.

Mulch presents some problems. On steep slopes, mulch will be washed downhill, while within the flood area, mulch will be carried away by flood waters. On steep slopes, mulch, even though it will offer patchy cover, will help to keep weed levels down. This can be assisted by placing barriers along the slope that will prevent the mulch from sliding right down the slope. Loosely weaving prunings and small branches together along the slope is one method of reducing the loss of mulch.

1.2.3 Categories of weeds

There are a huge variety of weeds that will invade and take over the natural ecosystems of the Auckland Region. A list is given in Appendix II. This list includes National Surveillance Plant Pests. A booklet of that name, complete with colour pictures to help with the identification of these weeds, is available from the Auckland Regional Council.

Weeds can be separated into the following three categories;

- Tree weeds - The methods of managing these within a planting is dealt with in the section about interplanting into existing vegetation
- Invasive weeds - these species are capable of invading natural ecosystems and altering patterns and processes. These weeds must be *eradicated thoroughly* before revegetation.
- Competitive weeds - these weeds compete with young native plants used in a revegetation project and are capable of overtopping and suppressing plantings. These species need to be controlled during

revegetation. This involves keeping the height of the weeds below the height of the planted natives. The competitive weeds should not be removed as they perform some very valuable functions in revegetation. Competitive weeds shade the soil and keep it moist, which helps prevent the planted natives from dying because of lack of water. They also stabilise the surface of the soil and prevent sediment washing into the stream.

1.2.4 Major weed species

The major invasive weeds and problem trees along streamsides will vary greatly from place to place in the Auckland Region.

Some of the more prevalent problems are:

- Willows
- Tree privet and Chinese privet
- Wandering jew
- Ginger
- Woolly nightshade
- Kikuyu
- Moth plant
- Blue morning glory & bindweed

For some of the invasive and problem tree weeds, Pestfact sheets are available from the Auckland Regional Council. Pestfact sheet No 51 is a list of these species (see Appendix II). Please note that these are not the only weeds that will cause problems during revegetation. Contact ARC Enviroline 09 – 366 2070 for any further advice and ask for a copy of the National Surveillance Plant Pests booklet to help you with identification.

1.3 Ecosourcing

In all situations, part of the answer to the question 'What will you plant, and where?' is that plants native to the local area should be used in stream bank plantings. The locality from which the seeds of plants were gathered is important because local populations are often adapted to local soil and climatic conditions. Not a lot is known about just how 'local' the source needs to be. To ensure the best results, a conservative approach should be taken, with the plants sourced closest to the planting site selected for planting.

In practice, it is unlikely, particularly for small projects, that plants sourced from the immediate local area will be available. Plants should definitely be grown from material gathered within the Auckland Region. It is, however, reasonable to aim more locally by obtaining plants from within the local Ecological District. There are seven Ecological Districts on the mainland of the Auckland Region. One, the Kaipara Ecological Region, is sufficiently different from the rest of the Auckland area to be separated into an Ecological Region of its own. The other Ecological Districts make up part of the Auckland Ecological Region.

The division into Ecological Regions and Districts should not be confused with the division into local government regions and districts. The ecological divisions are made on the grounds of biophysical characteristics, such as climate, geology and land use. The boundaries of the Ecological Regions and Districts do not coincide with local government boundaries. Figure 2 shows the Ecological Districts of the Auckland Region and also illustrates how these relate to the local government boundaries.

The Ecological Districts do differ in character from one another in topography and geology. This leads to different plant growing conditions. The following outline of the character of each Ecological District illustrates their differences and indicates the degree to which local sourcing may result in plants adapted for local conditions.

- **Kaipara Ecological Region** – The parts of the Kaipara Ecological Region that fall within the Auckland Region are mainly sandy soils, particularly on the South Kaipara and along the western edge of the Okahukura Peninsula. The body of the Okahukura Peninsula and the hills along the eastern coast of the harbour are of clay soils, while the stream and river valleys are of alluvial soils.
- **Rodney Ecological District** – Mainly clay soils on hill country, with considerable alluvial areas on the lower, flatter areas. At coastal localities there are some sandy soil areas and dune lakes, particularly at Pakiri.
- **Tamaki Ecological District** – Clay soils on gently rolling hill country, with considerable alluvial areas on the lower, flatter areas. Young basalt volcanic deposits coat a considerable proportion of the district.
- **Waitakere Ecological District** – Mainly clay soils on hill country, with a central, relatively high altitude area of andesitic volcanic deposits. This ecological district differs from the ecological district of the Hunua Ranges, as there is a high proportion of

Figure 2 Auckland Region Ecological District Boundaries

This diagram has been moved to ***Part 3 – Appendix B,***
which may be down loaded as a separate file

Figure 3 Distribution of substrate classes across the mainland of the Auckland Region.

This diagram has been moved to ***Part 3 – Appendix B,*** *which may be down loaded as a separate file*

volcanic material making up the clay soils. Small alluvial areas, but sizeable sandy soil areas in beach areas along the west coast.

- **Hunua Ecological District** – Mainly clay soils on greywacke hill country. There are some alluvial areas around the coast of the Firth of Thames and along river valleys, particularly the Wairoa River.
- **Manukau Ecological District** – Mainly alluvial soils. Pumice based and organic, with substantial peat flats at Ardmore. Volcanic soils around Pukekohe.
- **Awhitu Ecological District** – Mainly sandy soils, with short-run, low flow streams. Dune systems and dune lakes.

2.0 What to plant and where

This second section of the *Planting Guide* provides detailed planting schemes for 9 different stream bank situations defined mainly by substrate and topography. It forms an answer to the *Guideline* question 'What will you plant, and where?' for various substrates and topography. It focuses on a relatively narrow selection of native species that are able to establish in the harsh 'pioneer' conditions offered by open stream banks. These species need to be able to grow rapidly to out-compete a wide range of environmental weeds. A range of species typical of mature forest canopy that are hardy enough to establish within young pioneer vegetation augments these pioneer species. The parts of the stream bank profile that need to be planted and the substrates they are formed from provide the basis for selecting both pioneer and mature forest species.

The detailed planting schemes can be adapted to help solve the resource management problems identified in the first section. The performances and tolerances of native species outlined in Appendix III will allow appropriate species to be selected for individual conditions. More detail is given in section 2.5 about the ways of dealing with the various problems.

2.1 The Materials of the Stream Banks

The types of plants that will grow at a particular site will depend upon the soils. Plants often grow best in a particular soil type. For example, those plants able to grow well in sandy soils may not be able to survive in heavy clay soils.

Across the mainland of the Auckland Region there is substantial variation in the geology and soils. Stream banks will be made up of one of four main substrates: sandy soils, alluvial soils, clay soils or volcanic substrates. It is important to determine the substrate of the stream banks that are to be planted. This can be achieved by following Field Sheet 1 in the *Guideline*.

The definitions of the substrate types on geological grounds given in Appendix I will enable anyone to determine the exact substrate at their site by checking an appropriate geological map. Figure 3 shows the distribution of the substrate classes across the mainland of the Auckland Region.

Sections about each planting unit (2.3.1 to 2.3.9) and the table in Appendix III outline the species capable of growing in each of the major substrate types.

2.2 The Parts of the Stream Bank

Plants need to be placed in the correct part of the stream profile to survive and thrive. The types of plants that will successfully grow along damp stream edges will differ from those able to establish along the dry crest of the stream bank slope. A representative *stream profile* for the Auckland Region is shown in Figure 4 of this *Planting Guide.* For the purposes of defining parts of the stream profile for planting, the natural geomorphic parts of these profiles divide into up to four major *stream cross-section divisions,* shown in Figure 4. These are:

- **Stream edge** – The extreme stream edge is a site that is frequently damp and in which erosive forces are often considerable. When water reaches the top of the normal channel, it is still moving very quickly and has the potential to erode the bank at the top of the normal channel.
- **Flood area** – This part of the stream cross section is the stream flat and that part of the lower slope that is subjected to frequent flooding. Regular flooding is the defining characteristic of this division of the stream cross section. In all substrate types there may be a

stream flat of greater or lesser extent. Regular flooding will often extend up the toe of the adjacent slope. The height to which flooding regularly rises can be seen by visiting a site immediately after heavy prolonged rain. When waters overtop the normal channel, the velocity of the water drops and consequently the erosive force is usually comparatively low. Flood areas in all substrates, except for the more porous sandy soils, can be considered to be alike in planting conditions. They are usually of relatively high fertility and moisture compared to the adjacent slopes.

- **Back wetland or spring** – Where stream banks have accreted or streams have changed course or where springs emerge, there will be areas that remain wet for much of the year. The plants within these areas will need to be able to tolerate continuous wet conditions.
- **Slope** – Slopes of varying steepness, including cliffs, may be present in clay, volcanic alluvial or sand substrates. The conditions will be drier than on the stream flats, with dryness increasing towards the top of the slope. Different species will need to be planted on slopes of different substrates.

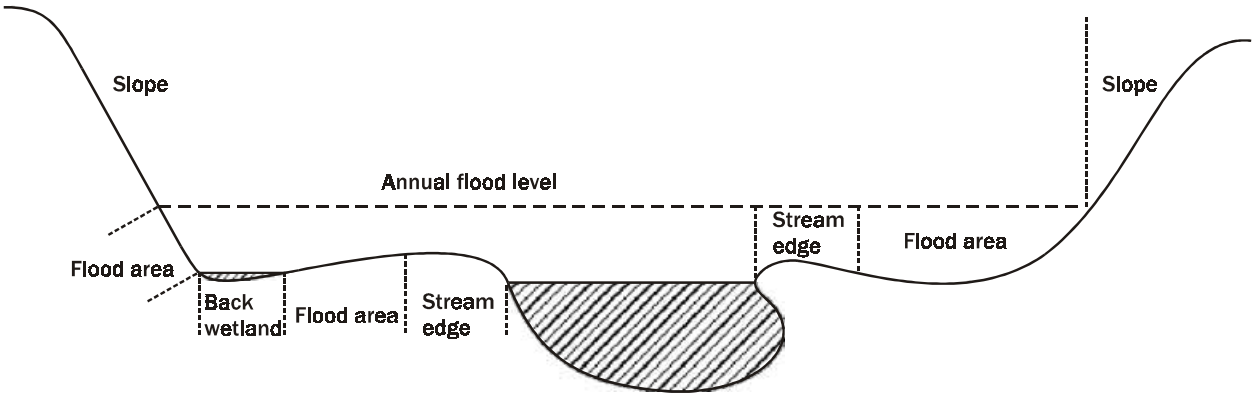
The position of a site within the stream cross-section is not the only factor that determines which species will establish well in a revegetation. The substrates that make up the parts of the stream cross-section as well as the salinity of the water introduce a great deal of variation in conditions. While saline areas have been excluded from the scope of these guidelines, the perennial streams that are included in fact merge into saline systems often without a distinct boundary and regularly quite some distance above the sea. These saline stretches are still very much streams, undergoing similar process of flooding and erosion and channel changes.

2.3 The Planting Units

A planting site needs to be divided into *planting units.* This is because the species that will successfully establish in a planting are determined by the substrate as well as by the position within the stream cross-section. These factors together determine the combination of planting medium and the amount (and erosive power!) of moisture. A third and overriding factor is salinity. Inundations of salty water onto stream edges and flats limits the plants that can grow on those areas to those that can tolerate salt. *Planting units* are therefore combinations of the cross-sectional divisions, the substrate, and the salinity of the water.

In general, the stream edge, the flood area and the back wetland or spring are similar in all substrate types with the exception of sandy soils. This is because they are all relatively fine grained substrates and are therefore less permeable than the sandy soils. Although volcanic substrates are usually highly porous, most of the streams through these are in catchments where there are also clay hills. The fine material from the clay hills generally intersperses the volcanic streamside material. However,

Figure 4 Stream cross-section divisions



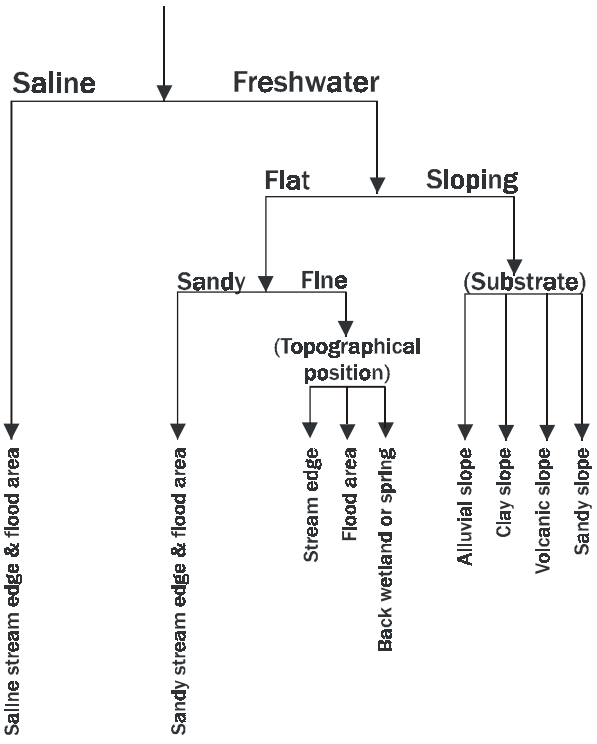
further up the bank, the substrate may be entirely rocky, so plants that survive well in rocky habitats are noted in the species table (Appendix III).

There are nine *planting units* that apply to the stream cross-sections and substrates found throughout the mainland of the Auckland Region. These are:

- Stream edge
- Flood area
- Back wetland or spring
- Clay slope
- Alluvial slope
- Volcanic slope
- Sandy slope
- Sandy stream edge and flood area
- Saline stream edge and flood area

In Figure 5, the planting unit classification shows the relative relationship of the planting units to one another. Salinity overrides all other factors, so the *saline stream edge and flood area planting unit* stands alone. The freshwater planting units are divided into groups on the basis of slope. The four planting units on sloping ground rising above the normal stream channel are in one group. The planting units on flatter ground nearer the normal stream channel are in another group, with the *sandy stream edge and flood area planting unit* then being separated from the other planting units on the basis of the texture and permeability of the substrate.

Figure 5 Planting units division hierarchy



The planting units can be 'mixed and matched' depending upon the stream cross-sectional divisions present (stream edge, flood area, back wetland or spring, slope) and the substrate (clay, volcanic, alluvial, sandy). Where sea water comes up a stream at high tide, the *saline stream edge and flood area planting unit* should be applied.

The following sections are descriptions of the vegetation to be planted on each of the planting units. For each planting unit, the following information is given:

- a description of the general conditions to be found in the open parts of the planting unit
- a description of the original mature vegetation of the planting unit
- a description of the major species to be planted in different parts of the planting unit, including pioneer plants and plants to produce a more diverse forest later on.
- a diagram of the mature revegetation on the planting unit showing the parts of the planting unit suitable for each species. The diagram shows the vegetation that ideally will have grown approximately 7 to 10 years after the commencement of the planting project
- a table of appropriate species indicating the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly).

The formal scientific name is given for each species the first time the plant is mentioned. This is because a number of plants may carry the same common name. For example, there are at least three species commonly referred to as mingimingi *(Coprosma propinqua, Cyathodes juniperina, and Leucopogon fasciculatus).* Each species grows in different conditions, so an error in identifying the intended species could result in failures in part of the revegetation.

2.3.1 Stream edge planting unit

The *stream edge planting unit* is found on the edges of stream channels in the clay, alluvial and volcanic soils of the Auckland Region. It applies to the lip of the bank of the channel that is sometimes raised and is sometimes undercut. Undercut sections of the stream edge function as an important shaded habitat for aquatic animals. Much of the time, the substrate of this part of the stream cross section is fine-grained and quite fertile, with alluvium commonly present. This planting unit is in a zone of high erosive potential and it is essential that this is recognised in planning which species to plant and when to plant them.

When planning a planting in the *stream edge planting unit,* it is important to understand that any plants present, particularly sedges and grasses, will perform a number of functions. These are:

1. Prevent weeds that have washed down from upstream establishing themselves on the stream bank.
2. Reduce erosion of the edge of the stream channel.
3. Prevent undercut banks from sliding into the stream, therefore providing an important stream wildlife habitat.
4. Filter contaminants and sediments out of runoff before it enters the stream.

For these reasons, this planting unit should be left untouched until the disturbance caused by weed control and planting on the bank has ceased. This strip along the stream will help to prevent the soil that is disturbed during the planting of the rest of the bank from being washed into the stream.

Apart from the occasional canopy tree growing right on the stream edge, such as kahikatea *(Dacrycarpus dacrydioides),* cabbage tree *(Cordyline australis)* and putaputaweta *(Carpodetus serratus),* much of the original mature vegetation of the *stream edge planting unit* never becomes particularly tall. Many species remain less than a metre in height and are able to lie flat when flood waters are rushing over them. They therefore do not stop the

Table 1 Species for Stream edge planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Carex dissita	Flat leaved sedge	Rush or sedge	✚✚	Prostrate plant will protect soil surface
Carex lessoniana	Rautahi	Rush or sedge	✚✚	Rhizomatous and spreads to hold unstable banks. Prostrate plant protects soil surface
Carex secta	Purei	Rush or sedge	✚✚	Prostrate plant will protect soil surface. Establishes particularly well on Auckland stream banks, even though it was not a particularly common species naturally. Can form short trunks.
Carex virgata	Small swamp sedge	Rush or sedge	✚✚	Prostrate plant will protect soil surface
Cyperus ustulatus	Giant umbrella sedge	Rush or sedge	✚✚	Prostrate plant will protect soil surface
Forest diversity planting				
Carpodetus serratus	Putaputaweta	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Cordyline australis	Cabbage tree (ti)	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Dacrycarpus dacrydioides	Kahikatea	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.

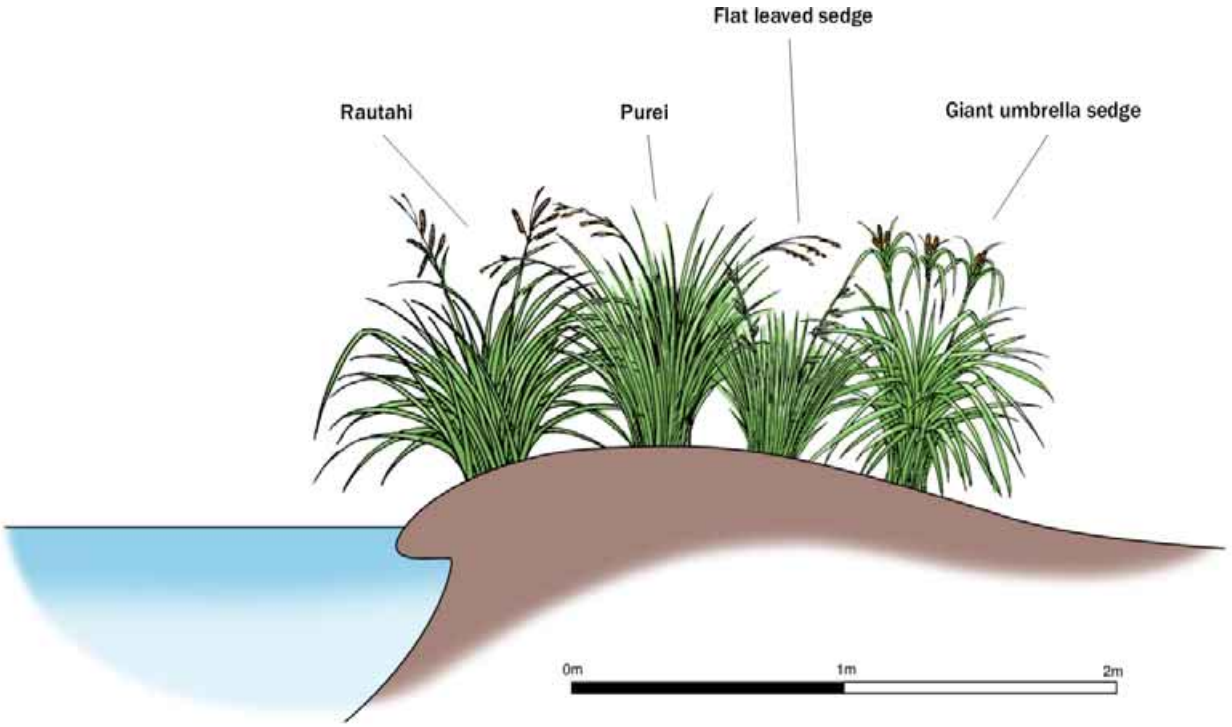
movement of flood waters, although they do seem to prevent erosion by slowing down a boundary layer of water immediately next to the soil surface. Sedges are commonly dominant on the stream edges. These include gahnia *(Gahnia setifolia)* and rautahi *(Carex lessoniana)*. Ferns, such as swamp kiokio *(Blechnum novae-zelandiae)* and gully fern *(Pneumatopteris pennigera)* are also fairly common.

Many of the species found in mature vegetation in this part of the stream cross section are able to tolerate high levels of shade and require damp conditions. These are not the sorts of environmental conditions that are present when the native vegetation has been removed from the riparian edge. Instead, conditions are hot and often dry, although floods will regularly happen and very high flows of fast moving water will cover this part of the stream bank at intervals during the year. The *stream edge planting unit* therefore cannot be initially replanted using all of the species that dominate in the mature vegetation. Later, some of the damp-loving tree species could be interspersed into the established planting to create forest diversity.

Plants that are used when re-establishing vegetation on this part of the stream bank need to be able to cope with the extreme environmental conditions mentioned above. Several species that are present to some degree in stream edges throughout the region establish well and grow vigorously when used in a revegetation in this part of the stream bank. Rautahi, small swamp sedge *(Carex virgata)*, purei *(Carex secta)*, flat leaved sedge *(Carex dissita)* and giant umbrella sedge *(Cyperus ustulatus)* are species that have been found to be very successful in this position in plantings throughout the region. All of these tolerate hot dry conditions and are able to lie flat when flood waters are flowing over them. Purei establishes particularly well on Auckland stream banks, even though it was not a particularly common species naturally. Rautahi is rhizomatous and will spread and hold unstable banks.

Flax (*Phormium tenax*) is not an appropriate species to use in areas where there is regular rapidly moving floodwater. When flax matures, it forms rigid fans, which offer considerable resistance to water flow. During floods, the water can push so hard against this rigid opposition that the plant is pulled completely out, taking a lump of the stream bank with it. Ferns tolerant of the extreme conditions, such as hard brake *(Pteris tremula)* and silver fern (or ponga) *(Cyathea dealbata)*, are not often planted into revegetation areas. This is because they have such tiny wide-ranging spores that they will frequently establish themselves even if the closest mature spore sources are growing some distance away.

Figure 6 Stream edge planting unit



2.3.2 Flood area planting unit

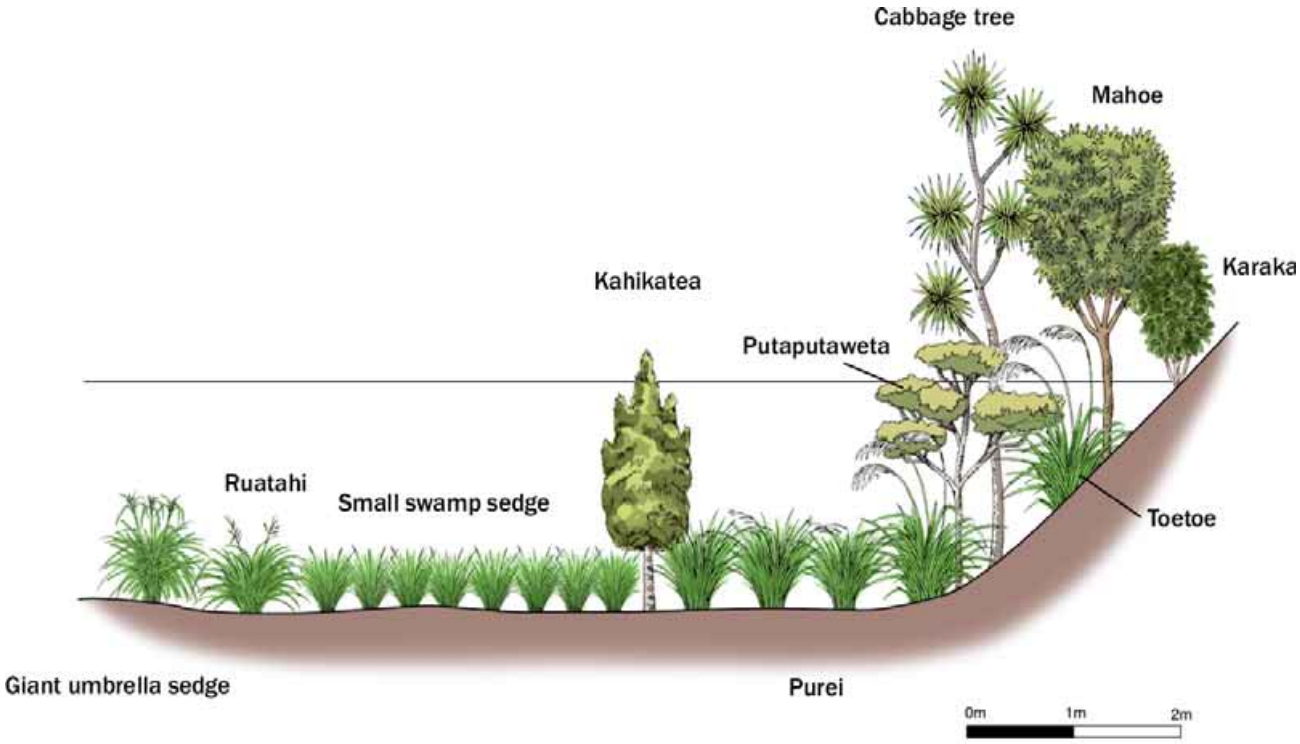
The *flood area planting unit* is very similar to the *stream edge planting unit.* It too is found on the clay, alluvial and volcanic soils of the Auckland Region and fine grained substrates and regular flooding are the defining characteristics of this planting unit. It covers any stream flat that is present and extends up the toe of the adjacent slope to the height which is reached regularly each year during peak flows. When waters overtop the normal channel and flow across the *flood area planting unit,* the velocity of the water drops and consequently the erosive force is usually relatively low, when compared to that of the *stream edge planting unit.* The lower erosive forces coupled with the buffering and filtering provided by the vegetation remaining in the *stream edge planting* unit mean that it is not necessary to maintain cover on the *flood area planting unit* until plantings further up the bank have established. The different timing required for revegetation means these parts of the stream bank, although supporting similar species, are considered to be separate planting units.

Flood areas with mature vegetation on all substrates, except for the more porous sandy soils, can be considered to be alike in environmental conditions. They are usually of relatively high fertility and moisture compared to the adjacent slopes. A variety of tree species, similar to those of the *stream edge planting unit,* thrive in these conditions. Major species include kahikatea, cabbage tree, putaputaweta and karaka *(Corynocarpus laevigatus).* Small trees and shrubs, such as the native fuchsia, kotukutuku *(Fuchsia excorticata)* and pate *(Schefflera digitata)* are present, with nikau *(Rhopalostylis sapida),* mamaku *(Cyathea medullaris),* gully fern, swamp kiokio and tangles of kiekie *(Freycinnetia baueri)* common.

Again, the species of the mature vegetation specialise in the cool damp conditions found in the established forest, with most species likely to die if exposed to the hot dry conditions found at a revegetation site. Some of these are appropriate to interplant later into the established planting to foster forest diversity.

In the initial revegetation, the same variety of sedges that will grow well on the stream edge will establish well in the *flood area planting unit* revegetation. These are rautahi, small swamp sedge, purei, flat leaved sedge and giant umbrella sedge.

Figure 7 Flood area planting unit
Maturing pioneer planting with recent forest diversity planting



A key species has been found to be toetoe *(Cortaderia fulvida)*. It is an effective species to use as the dominant plant in the *flood area planting unit.* Like the sedges listed above, it lies flat in a flood. It is extremely tolerant of dry conditions. Interspersed with the sedges, toetoe could make up 50% of the planting on the flood plain. It is particularly useful because it grows into an 'umbrella' form, which partially shades the soil and surrounding plants, keeping moisture levels higher and helping surrounding plants to establish strongly. Toetoe is also tolerant of disturbed substrates, where earth moving has mixed up soil horizons and there is only a low organic content in the upper horizons of the soil. For this reason, it is a particularly good species to use on the toe slope part of the flood. Here it can be interspersed with cabbage trees planted at 3m intervals. Mahoe *(Melicytus ramiflorus)* can also be interspersed with the toetoe as it forms a very good root system that helps to stabilise the bank

Toetoe is a much better species to use than flax where there will be rapidly moving floodwaters. As mentioned for the previous planting unit, flax is not an appropriate species to use in such areas. The pressure of water during flooding will often tear out the rigid fan of the mature flax taking part of the stream bank with it.

Table 2 Species for Flood area planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Carex dissita	Flat leaved sedge	Rush or sedge	✚✚	Plant on flat. Prostrate plant protects soil surface.
Carex lessoniana	Rautahi	Rush or sedge	✚✚	Plant on flat. Rhizomatous and spreads to hold unstable banks. Prostrate plant protects soil surface.
Carex secta	Purei	Rush or sedge	✚✚	Plant on flat. Prostrate plant protects soil surface. Establishes particularly well on Auckland stream banks, even though it was not a particularly common species naturally. Can form short trunks.
Carex virgata	Small swamp sedge	Rush or sedge	✚✚	Plant on flat. Prostrate plant protects soil surface.
Cordyline australis	Cabbage tree (ti)	Tree	✚	Toe slope. The single trunk offers low resistance to flood waters. Bird-distributed.
Cortaderia fulvida	Toetoe	Grass (clump former)	✚✚✚	Flat and toe slope. Smallest of the toetoes. Can be distinguished from invasive pampas by its drooping flowering spike. Able to grow on dry, disturbed, compacted sites.
Cyperus ustulatus	Giant umbrella sedge	Rush or sedge	✚✚	On flat. Prostrate plant will protect soil surface.
Melicytus ramiflorus	Mahoe	Tree	✚	Toe slope. Forms well developed root system that stabilises banks
Forest diversity planting				
Carpodetus serratus	Putaputaweta	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Corynocarpus laevigatus	Karaka	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Dacrycarpus dacrydioides	Kahikatea	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.

Table 3 Species for Back wetland or spring planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Blechnum novae-zelandiae	Swamp kiokio	Fern	✚	Plant on margin. Is a hardy plant that is widespread throughout the region.
Carex lessoniana	Rautahi	Rush or sedge	✚✚	Rhizomatous and spreads to hold unstable banks. Prostrate plant protects soil surface
Carex secta	Purei	Rush or sedge	✚✚	Prostrate plant will protect soil surface. Establishes particularly well on Auckland stream banks, even though it was not a particularly common species naturally. Can form short trunks.
Carex virgata	Small swamp sedge	Rush or sedge	✚✚	Prostrate plant will protect soil surface
Cordyline australis	Cabbage tree (ti)	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Cyperus ustulatus	Giant umbrella sedge	Rush or sedge	✚✚	Plant on margin. Prostrate plant will protect soil surface
Leptospermum scoparium	Manuka	Small tree	✚✚	Plant on margin. Very hardy and grows vigorously, but needs to be planted in autumn and must not have roots disturbed when being transplanted.
Pneumatopteris pennigera	Gully fern	Fern	✚	Plant on margin. Can form short trunks. Requires damp and shaded position.
Schefflera digitata	Pate	Small tree	✚	Plant on margin. Grows rapidly in damp sites, particularly if there is some shade.
Forest diversity planting				
Dacrycarpus dacrydioides	Kahikatea	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Laurelia novae-zelandiae	Pukatea	Tree	✚	Slow growing, but characteristic of wet sites. The single trunk offers low resistance to flood waters.
Syzygium maire	Swamp maire	Tree	✚	Needs moisture. Bird-distributed. The single trunk offers low resistance to flood waters.

2.3.3 Back wetland or spring planting unit

On fine-grained substrates, where stream banks have accreted or streams have changed course or where springs emerge, there will be areas that remain wet for much of the year. The *back wetland or spring planting unit* can be found on clay, alluvial and volcanic substrates. Springs fed by aquifers are particularly common at the base of lava flows. The plants growing within these wet areas will need to be able to tolerate continuous wet conditions.

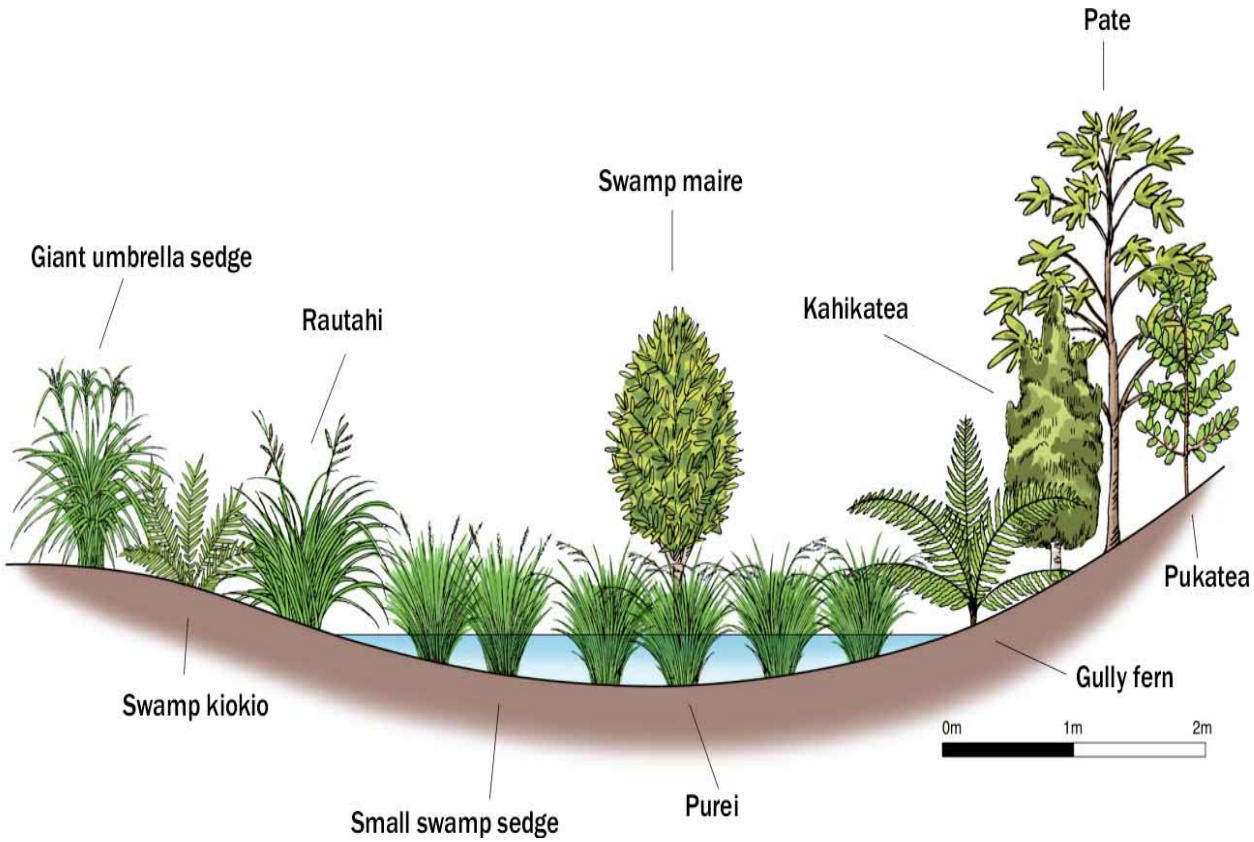
There is little information about species that are naturally found in these small pockets of permanently wet soils along the stream banks of the Auckland Region. However, there are a variety of species that are able to tolerate permanently wet conditions that are occasionally subjected to the forces of swiftly moving flood waters.

Purei, rautahi and small swamp sedge are all able to survive prolonged immersion. Cabbage trees and manuka *(Leptospermum scoparium)*, both of which are able to tolerate these conditions, can be interspersed amongst these. Problems can arise when planting into the very soft substrates in the permanently wet areas. Newly establishing plants are not securely anchored and can be washed out by flood waters. Pukeko will also come along and pull up plants, particularly sedges, from the slurry into which they have been planted.

On the margins of these small wetland pockets, a number of species can be planted that tolerate high light levels if moisture levels remain high. These include giant umbrella sedge, swamp kiokio, gully fern and pate.

To encourage a more diverse and taller stature forest, a number of tree species can be planted later into the established vegetation in these wetland pockets. Pukatea *(Laurelia novae-zelandiae)*, swamp maire *(Syzygium maire)* and kahikatea are all able to tolerate prolonged immersion.

Figure 8 Back wetland or spring planting unit
Maturing pioneer planting with recent forest diversity planting



2.3.4 Clay slope planting unit

Clay slopes of varying steepness may rise above the regularly flooded parts of the stream cross-section. The conditions will be drier than on the stream flats, with dryness increasing towards the top of the slope. It is on these slopes, where flooding has ceased to be a controlling factor, that substrate becomes the dominant factor to be considered.

Mature forests on the *clay slope planting unit* would have been diverse in composition with a wide variety of tree species present. On the lower slope, above the frequently flooded zone, but where fertility was still quite high, karaka, kohekohe *(Dysoxylum spectabile)* and puriri *(Vitex lucens)* would have been major species, with totara *(Podocarpus totara)*, tawa *(Beilschmiedia tawa)*, and taraire *(Beilschmiedia tarairi)* a little further upslope. Rimu *(Dacrydium cupressinum)* and kauri *(Agathis australis)* would have been present at the tops of slopes.

To establish a young forest cover capable of growing quickly to form a closed canopy above weeds, yet able to survive the hot dry conditions of the open *clay slope planting unit,* a different range of species need to be considered. The young forest should be mainly of nursery species that will allow other forest canopy species to grow beneath the young canopy when it has formed.

Toetoe can still be used to ameliorate the soil conditions with its umbrella-shaped form and cabbage tree will also grow in these drier sites. Above the frequent flooding zone, where blocking the flow is not a problem every year, flax can be used. This is a species that grows well in these difficult conditions and provides bird food when it flowers, perhaps as rapidly as two years after planting. Another valuable species that can be used in quantity and will provide berries for bird food rapidly is karamu *(Coprosma robusta)*.

Kanuka *(Kunzea ericoides)* and manuka will also serve this nursery function. However, both of these species need special care when planting. They are highly susceptible to root disturbance and need to be slid into the ground with as little movement of the potting mix as possible. These species are known for surviving in dry forests, but this is more the case when they have grown on site from seed. When grown from transplanted plants, they are less able to grow in dry positions, although planting in autumn rather than spring will aid their establishment. Mahoe is also able to survive in the drier positions, although it will take it a year before it starts to establish vigorously. Mapou *(Myrsine australis),* on the other hand, is able to establish quite well on clay banks, but is less of a nursery species than the other species listed above.

When the young forest has achieved canopy closure, a more diverse and taller stature forest can be encouraged by planting a number of tree species within the new vegetation. Karaka, kohekohe, and puriri could be sprinkled into the vegetation in the lower parts of the *clay slope planting unit,* while to the lower slope vegetation, with totara, rimu and kauri being planted progressively further up the slope. Tawa and taraire are difficult to establish in plantings.

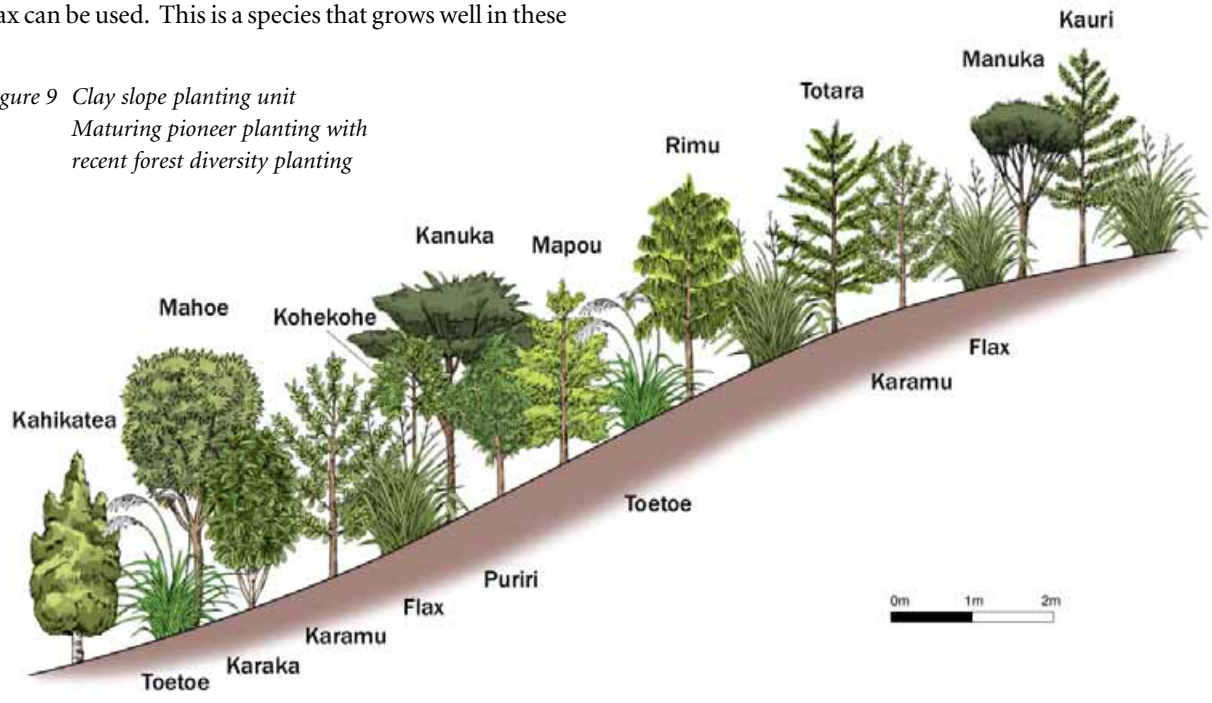


Figure 9 Clay slope planting unit
Maturing pioneer planting with recent forest diversity planting

Table 4 Species for Clay slope planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (+++ = use plentifully, ++ = use commonly, + = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Coprosma robusta	Karamu	Shrub	+++	Fast-growing shade tolerant species. Bird-distributed, with abundant autumn berries for birds.
Cordyline australis	Cabbage tree (ti)	Tree	+	Bird-distributed. Hardy.
Cortaderia fulvida	Toetoe	Grass (clump former)	+++	Smallest of the toetoes. Can be distinguished from invasive pampas by its drooping flowering spike. Able to grow on dry, disturbed, compacted sites
Kunzea ericoides	Kanuka	Tree	++	Major nursery species. Needs to be planted in autumn and must not have roots disturbed when being transplanted. Forms well developed root system that stabilises banks
Leptospermum scoparium	Manuka	Small tree	++	Major nursery species. Needs to be planted in autumn and must not have roots disturbed when being transplanted. Grows vigorously and has a wide ecological tolerance, including the ability to colonise inhospitable, low fertility sites. Forms well developed root system that stabilises banks.
Melicytus ramiflorus	Mahoe	Tree	++	Forms well developed root system that stabilises banks. Best planted in autumn. Establishes more slowly than other bank stabilising species, but is a very common species in young riparian vegetation throughout the region. Very fast growing when it becomes established. Bird-distributed.
Myrsine australis	Mapou	Tree	+	Bird-distributed.
Phormium tenax	Flax	Monocot clump former	+++	Very hardy with wide environmental tolerances.
Forest diversity planting				
Agathis australis	Kauri	Tree	+	Survives in infertile soils.
Corynocarpus laevigatus	Karaka	Tree	+	Bird-distributed.
Dacrycarpus dacrydioides	Kahikatea	Tree	+	Bird-distributed.
Dacrydium cupressinum	Rimu	Tree	+	Bird-distributed. Midslope species.
Dysoxylum spectabile	Kohekohe	Tree	+	Bird-distributed.
Podocarpus totara	Totara	Tree	+	Survives well on dry and exposed sites. Bird-distributed.
Vitex lucens	Puriri	Tree	+	Prefers fertile sites. Bears flowers and berries all year round, so is therefore a valuable food source. Bird-distributed.

Table 5 Species for Alluvial slope planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Alectryon excelsus	Titoki	Tree	✚	Prefers fertile sites. Bird-distributed.
Coprosma robusta	Karamu	Shrub	✚✚✚	Fast-growing shade tolerant species. Bird-distributed, with abundant autumn berries for birds.
Cordyline australis	Cabbage tree (ti)	Tree	✚	Bird-distributed. Hardy.
Cortaderia fulvida	Toetoe	Grass (clump former)	✚✚✚	mallest of the toetoes. Can be distinguished from invasive pampas by its drooping flowering spike. Able to grow on dry, disturbed, compacted sites
Kunzea ericoides	Kanuka	Tree	✚✚	Major nursery species. Needs to be planted in autumn and must not have roots disturbed when being transplanted. Forms well developed root system that stabilises banks
Leptospermum scoparium	Manuka	Small tree	✚✚	Major nursery species. Needs to be planted in autumn and must not have roots disturbed when being transplanted. Grows vigorously and has a wide ecological tolerance, including the ability to colonise inhospitable, low fertility sites. Forms well developed root system that stabilises banks.
Melicytus ramiflorus	Mahoe	Tree	✚✚	Forms well developed root system that stabilises banks. Best planted in autumn. Establishes more slowly than other bank stabilising species, but is a very common species in young riparian vegetation throughout the region. Very fast growing when it becomes established. Bird-distributed.
Myrsine australis	Mapou	Tree	✚	Bird-distributed.
Phormium tenax	Flax	Monocot clump former	✚✚✚	Very hardy with wide environmental tolerances.
Sophora microphylla	Kowhai	Tree	✚	
Forest diversity planting				
Corynocarpus laevigatus	Karaka	Tree	✚	Bird-distributed.
Dysoxylum spectabile	Kohekohe	Tree	✚	Bird-distributed.
Podocarpus totara	Totara	Tree	✚	Survives well on dry and exposed sites. Bird-distributed.
Prumnopitys taxifolia	Matai	Tree	✚	Slow growing, but characteristic of more fertile sites. Bird-distributed.
Vitex lucens	Puriri	Tree	✚	Prefers fertile sites. Bears flowers and berries all year round, so is therefore a valuable food source. Bird-distributed.

2.3.5 Alluvial slope planting unit

The *alluvial slope planting unit* is in many ways similar to clay slopes. However, the alluvial areas are rather lower and less hilly than the clay areas, so the slopes tend to be correspondingly lower. The variation in dryness from the top of the slope down to the part of the slope immediately above the frequently flooded zone is much less likely to be a major factor of variation than it is on the clay areas. In addition, the substrate is often somewhat more fertile than on the older, more leached clay hills.

Mature forests on the *alluvial slope planting unit* would also have been diverse in composition with a wide variety of tree species present. As on the more fertile and damper parts of the *clay slope planting unit,* karaka, kohekohe, puriri, taraire, tawa and totara would have been major species. Additional species not common on the clay hills would have been kowhai *(Sophora microphylla),* titoki *(Alectryon excelsus),* and matai *(Prumnopitys taxifolia).*

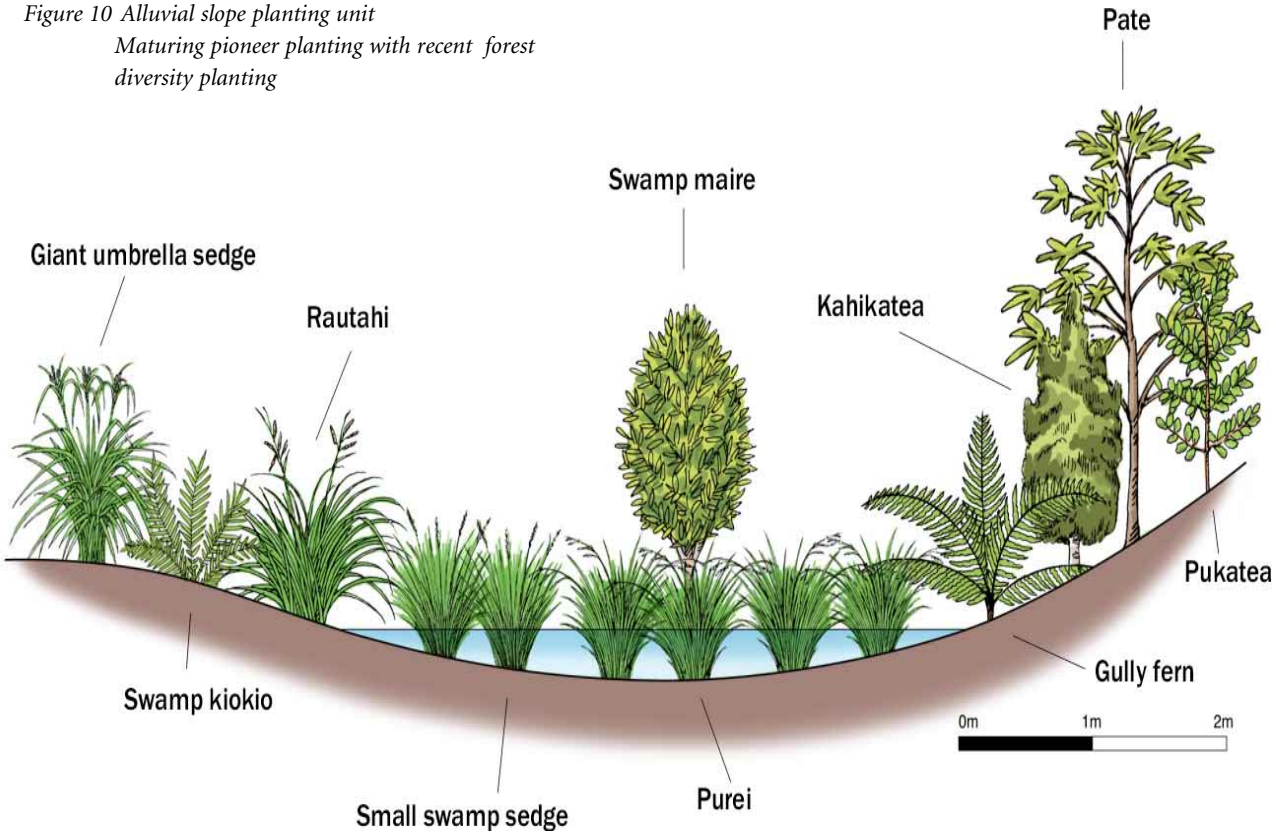
Again, conditions in cleared sections of *alluvial slope planting unit* would be too dry and hot for the establishment of most of the trees that are characteristic of the mature vegetation. Revegetation should consist of the same species that are planted on *clay slope planting unit.* Again, the young forest should be mainly of nursery species that will allow other forest canopy species to grow beneath the young canopy when it has formed.

On the *alluvial slope planting unit,* toetoe with its umbrella form shading the surrounding soil and plants will help many other species establish. Cabbage trees will survive and establish well in these conditions as will young kowhai and titoki. All three of these species are able to gain considerable stature as forest trees. Flax and karamu, with their rapid establishment and their development as a food resource for birds should also be major components in a revegetation on this planting unit.

Kanuka and manuka can also be used as nursery species. They are highly susceptible to root disturbance and should be planted in autumn rather than spring. Mahoe is also an effective nursery species on the *alluvial slope planting unit.* Mapou will also establish well on alluvial slopes, but is less of a nursery species than the other species listed above.

Forest diversity can be encouraged by planting other tree species into the vegetation when the canopy of the young forest has closed. Karaka, kohekohe, puriri and totara may be planted amongst the young forest as can matai, particularly at the bottom of the slope.

Figure 10 Alluvial slope planting unit
Maturing pioneer planting with recent forest diversity planting



2.3.6 Volcanic slope planting unit

Volcanic slopes may form one or both banks of a stream. In the younger volcanic areas, the streams skirt the sides and ends of lava flows, so only a single bank will be of volcanic material. The substrate of the *volcanic slope planting unit* is very free-draining and fertile, but may have a large amount of volcanic rock present, offering therefore only a limited space within which plant roots can grow. Within the regularly flooded parts of the stream bank, the interstices between rocks will be filled with a fertile, fine-grained material.

Mature forests on the *volcanic slope planting unit* would have been of fertility-loving broadleaf tree species, similar in many ways to the broadleaf forests of the coast. Pohutukawa *(Metrosideros excelsa),* titoki, puriri, kohekohe, karaka, and mangeao *(Litsea calicaris)* would all have been major species of this forest. Beneath this canopy would have been a variety of small trees and large shrubs, such as mapou, large-seeded karamu *(Coprosma macrocarpa)* and kawakawa *(Macropiper excelsum),* over a tier of specialist groundcover plants, such as *Astelia banksii* and hounds tongue fern *(Phymatosorus diversifolius).*

The conditions within an established lava flow forest are a lot moister and shadier than in the open *volcanic slope planting unit.* The young forests of Rangitoto indicate the species capable of establishing in this open, rocky, hot and dry environment. Pohutukawa, although a large tree species is able to establish on bare rock. This is a useful species to use as a nursery species as its shade is not dense and many plants are able to thrive under its protection. This can be planted quite closely as the trees will thin themselves out once canopy closure has been attained. Other species that will grow well in this environment include koromiko *(Hebe stricta* var. *stricta),* mapou, mahoe, karamu, and akepiro *(Olearia furfuracea).* Manuka can also establish in pockets in this substrate.

Figure 11 Volcanic slope planting unit
Maturing pioneer planting with recent forest diversity planting

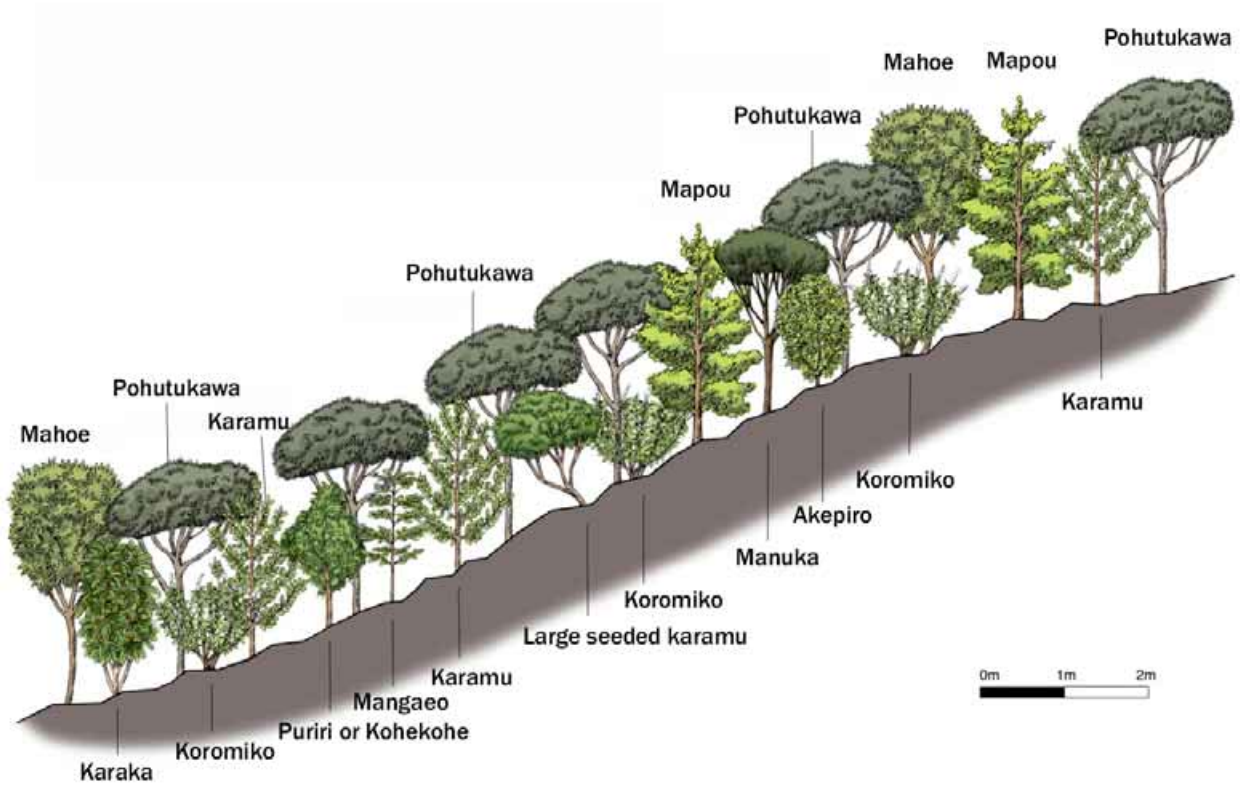


Table 6 Species for Volcanic slope planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Alectryon excelsus	Titoki	Tree	✚	Prefers fertile sites. Bird-distributed.
Coprosma robusta	Karamu	Shrub	✚✚	Fast-growing shade tolerant species. Bird-distributed, with abundant autumn berries for birds.
Hebe stricta var. *stricta*	Koromiko	Shrub	✚✚	Very hardy.
Leptospermum scoparium	Manuka	Shrub	✚	Needs to be planted in autumn and must not have roots disturbed when being transplanted. Grows vigorously and has a wide ecological tolerance, including the ability to colonise inhospitable sites. Forms well developed root system that stabilises banks.
Melicytus ramiflorus	Mahoe	Tree	✚✚	Forms well developed root system that stabilises banks. Best planted in autumn. Establishes more slowly than other bank stabilising species, but is a very common species in young riparian vegetation throughout the region. Very fast growing when it becomes established. Bird-distributed.
Myrsine australis	Mapou	Tree	✚✚	Bird-distributed. Characteristic species of young lava flow vegetation.
Metrosideros excelsa	Pohutukawa	Tree	✚✚✚	Establishes more slowly than other bank stabilising species. Will grow well developed and far-reaching root system. Most important lava flow nursery species.
Olearia furfuracea	Akepiro	Shrub	✚	
Forest diversity planting				
Coprosma macrocarpa	Large-seeded karamu	Small tree	✚	Bird-distributed.
Corynocarpus laevigatus	Karaka	Tree	✚	Bird-distributed.
Dysoxylum spectabile	Kohekohe	Tree	✚	Bird-distributed.
Litsea calicaris	Mangeao	Tree	✚	Difficult to grow, but is an important and characteristic species on volcanic rocky substrates. Bird-distributed
Vitex lucens	Puriri	Tree	✚	Prefers fertile sites. Bears flowers and berries all year round, so is therefore a valuable food source. Bird-distributed.

Table 7 Species for Sandy slope planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Coprosma lucida	Shining karamu	Shrub	✚✚	Fast-growing shade tolerant species that is capable of growing well beneath a canopy or beneath gorse. Bird-distributed.
Coprosma robusta	Karamu	Shrub	✚✚	Fast-growing shade tolerant species that is capable of growing well beneath a canopy or beneath gorse. Bird-distributed, with abundant autumn berries for birds.
Kunzea ericoides	Kanuka	Tree	✚✚	Major nursery species. Needs to be planted in autumn and must not have roots disturbed when being transplanted. Forms well developed root system that stabilises banks
Leptospermum scoparium	Manuka	Small tree	✚✚	Major nursery species. Needs to be planted in autumn and must not have roots disturbed when being transplanted. Grows vigorously and has a wide ecological tolerance, including the ability to colonise inhospitable, low fertility sites. Forms well developed root system that stabilises banks.
Melicytus ramiflorus	Mahoe	Tree	✚✚	Forms well developed root system that stabilises banks. Best planted in autumn. Establishes more slowly than other bank stabilising species, but is a very common species in young riparian vegetation throughout the region. Very fast growing when it becomes established. Bird-distributed.
Forest diversity planting				
Agathis australis	Kauri	Tree	✚	Survives in infertile soils.
Corynocarpus laevigatus	Karaka	Tree	✚	Bird-distributed
Dysoxylum spectabile	Kohekohe	Tree	✚	Bird-distributed
Metrosideros excelsa	Pohutukawa	Tree	✚	Establishes more slowly than other bank stabilising species. Tolerates inhospitable environments, including exposed ridge tops. Will grow well developed and far-reaching root system. .
Podocarpus totara	Totara	Tree	✚	Survives well on dry and exposed sites. Bird-distributed
Vitex lucens	Puriri	Tree	✚	Prefers fertile sites. Bears flowers and berries all year round, so is therefore a valuable food source. Bird-distributed.

2.3.7 Sandy slope planting unit

The *sandy slope planting unit* is seasonally drier than other planting units as the porous sandy soils dry more rapidly than most other substrates in the region. For this reason, planting should take place when the substrate is thoroughly wet and likely to remain so. Late autumn and early winter plantings are less likely to suffer moisture deficits than those planted in spring or early autumn.

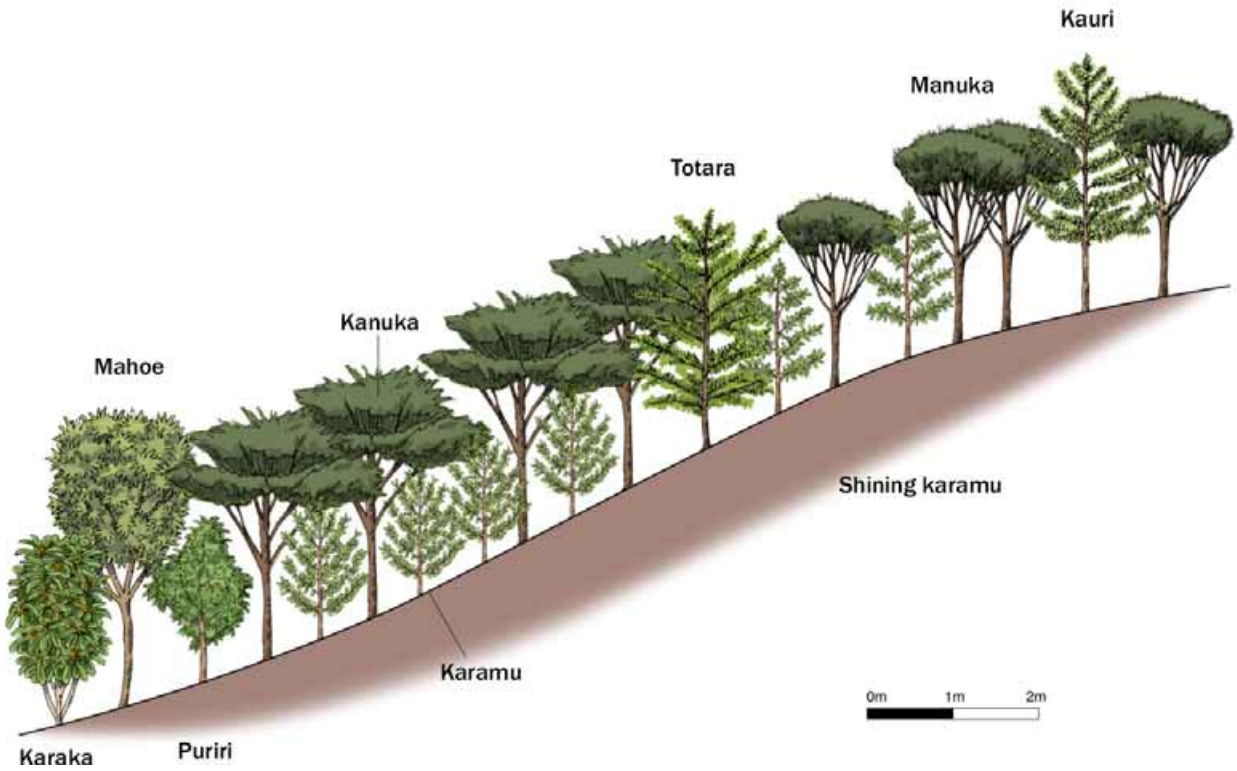
Mature forests on the *sandy slope planting unit* would also have been diverse in composition with a wide variety of tree species present. As on the more fertile and damper parts of the *clay slope planting unit,* karaka, kohekohe, puriri, taraire, tawa and totara would have been major species. Further upslope, a range of species tolerant of the drier conditions would have grown, including kauri and tanekaha and sometimes pohutukawa.

Establishing a young forest cover on open areas on the freely draining and often very dry sandy soils of these slopes means that species tolerant of dry conditions need to be used. The young forest should be mainly of nursery species that will allow other forest canopy species to grow beneath the young canopy when it has formed.

In existing plantings on sandy soils across the region, both manuka and kanuka have found to be successful, particularly if the plants are small and are planted in early winter. Manuka is able to establish on the infertile and dry tops of the slopes, while kanuka will establish on the more fertile and well drained portions of the slope. Mahoe grows naturally in young vegetation on the sandy slopes and should be able to establish well on the slopes if planted during the damp parts of the year. Karamu is able to establish well in the conditions that exist on these slopes and shining karamu *(Coprosma lucida)* can grow in the drier more infertile upper slope areas. Both of these species will provide valuable bird food quite rapidly.

Forest diversity can be encouraged by planting other tree species into the vegetation when the canopy of the young forest has closed. Kauri can be planted on relatively infertile parts of the tops of the slopes, while pohutukawa will survive on more fertile exposed ridge crests. Totara is an appropriate species to plant in the mid slope area, while karaka, kohekohe, or puriri will be able to survive on the lower parts of the slope.

Figure 12 Sandy slope planting unit
Maturing pioneer planting with recent forest diversity planting



2.3.8 Sandy stream edge and flood area planting unit

The *sandy stream edge and flood area planting unit* differs from the stream edges and flats in other substrate types because the surrounding land is more permeable. Water rapidly percolates down through the ground and perennial streams will only flow in those valley bottoms where the water table is high all year around. This means that perennial streams are frequently associated with boggy areas and wetlands.

While frequently being in a boggy area, *the sandy stream edge and flood area planting unit* will also sometimes become very dry. It is made up of a porous substrate, with lower levels of water-retaining clay minerals than either the clay or alluvial substrates or the more weathered volcanic substrates throughout the region. Species that survive in this planting unit are those that will tolerate occasional droughty conditions as well as prolonged damp periods and the considerable pressure of rapidly moving flood waters

Small swamp sedge and swamp kiokio are both able to tolerate these conditions as are giant umbrella sedge, and pohuehue (or wirevine) *(Muehlenbeckia complexa)*. Cabbage trees and manuka, both of which are able to tolerate these conditions, can be interspersed amongst these. If the boggy area is quite wide, then flax can be planted. In these places, the pressure of water during flooding will not be strong enough to tear out the rigid fan of the mature flax.

To encourage a more diverse and taller stature forest, a number of tree species can be planted later into the established vegetation in these wetland pockets. Kahikatea, putaputaweta, pukatea and swamp maire are all mature forest species found on the flats within sandy parts of the region.

In other parts of the valley bottoms, there will be associated wetland areas without substantial water flow. It may be practical to plant these areas at the same time as the stream bank itself. Many of the species listed above will be suitable for these areas. There are a wide variety of other wetland species that will thrive in these conditions. These include raupo *(Typha orientalis)*, lake clubrush *(Schoenoplectus validus), Baumea juncea, Baumea rubiginosa,* and sharp spike-sedge *(Eleocharis acuta)*.

Figure 13 Sandy stream edge and flood area planting unit
Maturing pioneer planting with recent forest diversity planting

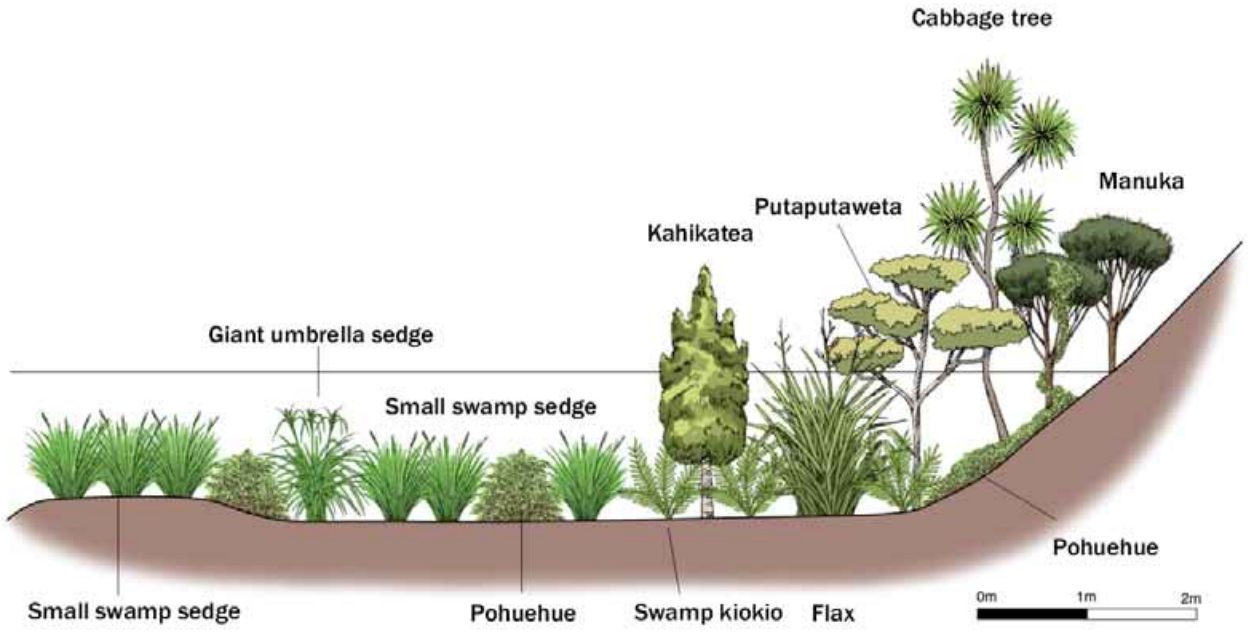


Table 8 Species for Sandy stream edge and flood area planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (+++ = use plentifully, ++ = use commonly, + = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Blechnum novae-zelandiae	Swamp kiokio	Fern	++	Is a hardy plant that is widespread throughout the region.
Carex virgata	Small swamp sedge	Rush or sedge	+++	Prostrate plant will protect soil surface
Cordyline australis	Cabbage tree (ti)	Tree	+	Bird-distributed. The single trunk offers low resistance to flood waters.
Cyperus ustulatus	Giant umbrella sedge	Rush or sedge	++	Prostrate plant will protect soil surface
Leptospermum scoparium	Manuka	Small tree	++	Very hardy and grows vigorously, but needs to be planted in autumn and must not have roots disturbed when being transplanted.
Muehlenbeckia complexa	Pohuehue (wirevine)	Vine	+	Grows rapidly. Scrambles over shrubs or forms hummocks on open ground.
Phormium tenax	Flax	Monocot clump former	++	Very hardy with wide environmental tolerances. On wide flood areas, this species can be planted widely as resistance to flood water flow is not such a problem as in narrow and confined systems.
Forest diversity planting				
Carpodetus serratus	Putaputaweta	Tree	+	Bird-distributed. The single trunk offers low resistance to flood waters.
Dacrycarpus dacrydioides	Kahikatea	Tree	+	Bird-distributed. The single trunk offers low resistance to flood waters.
Laurelia novae-zelandiae	Pukatea	Tree	+	Slow growing, but characteristic of wet sites. The single trunk offers low resistance to flood waters.
Syzygium maire	Swamp maire	Tree	+	Needs moisture. Bird-distributed. The single trunk offers low resistance to flood waters.

2.3.9 Saline stream edge and flood area planting unit

The *saline stream edge and flood area planting unit* is found in the lower reaches of the streams of the Auckland Region. They reach as far upstream as saline inundations. These saline limits do not correspond with the river mouth boundaries given in the Regional Plan: Coastal, which tend to be sensible administrative boundaries rather than extreme limits of the salt water influence.

Determining the extent of the *saline stream edge and flood area planting unit* is not always easy. In some cases native species of the saline environment, like those in the vegetation diagrams, will be present. In other cases, weeds of the saline environment will predominate. These include Mercer grass *(Paspalum distichum),* kikuyu *(Pennisetum clandestinum),* and tall fescue *(Festuca arundinacea).* It is important to work out this extent correctly, as a saltwater inundation will kill plantings of many of the species that specialise on the edges, flats, and back wetlands of freshwater streams.

The original mature vegetation of the *saline stream edge and flood area planting unit* never becomes particularly tall. Much of the vegetation reaches less than a metre in height. The species are distributed according to position of the edge and flat in the manner shown in the profile diagram of the mature vegetation of this planting unit. Jointed wirerush *(Leptocarpus similis)* and sometimes sea rush *(Juncus maritimus)* are present on the stream edge, along with saltmarsh ribbonwood *(Plagianthus divaricatus).* On the stream flat, marsh clubrush *(Bolboschoenus fluviatilis)* is often present in quantities. Flax is also present, as is pohuehue (wirevine). Cabbage trees and manuka are often able to survive at the toe of the slope, particularly in the intermittently saline areas. Pohutukawa and kowhai are likewise able to manage near the foot of saline slopes.

The *saline stream edge and flood area planting unit* can be replanted with the species present in the mature vegetation. All of these species are able to survive at an early stage in vegetation development as the moisture availability and light levels in these young plantings are very similar to those in the mature vegetation.

Figure 14 Saline stream edge and flood area planting unit

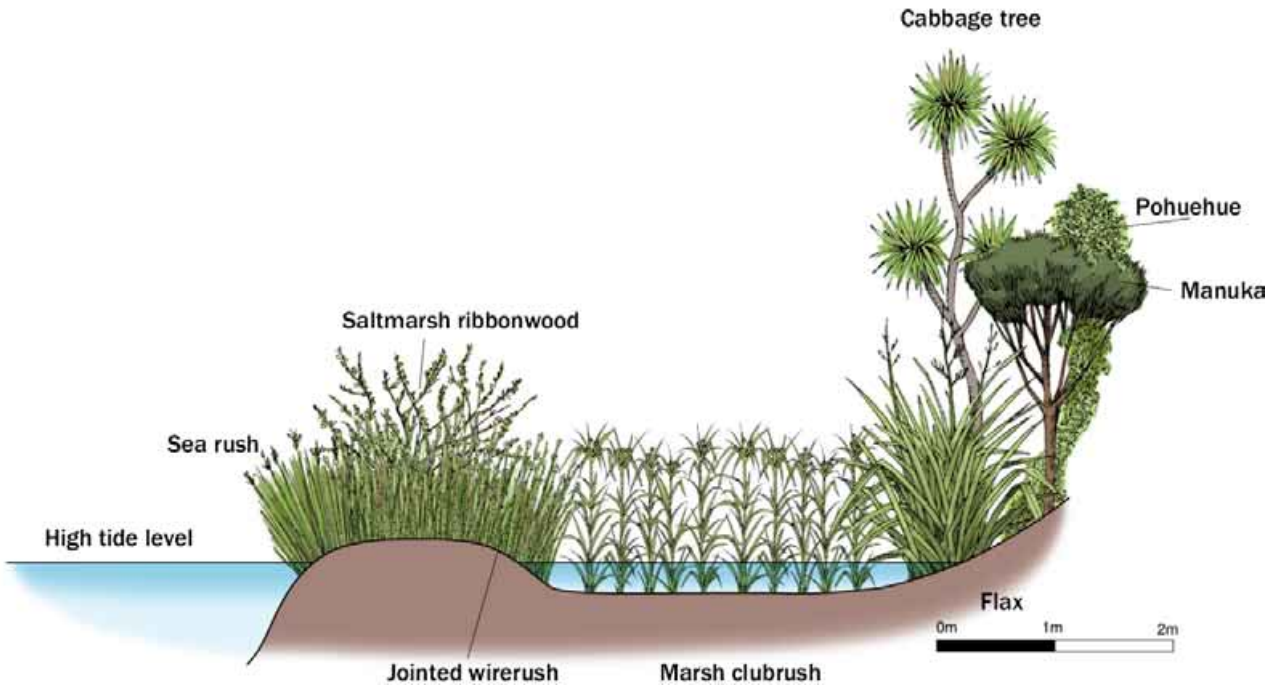


Table 9 Species for Saline stream edge and flood area planting unit

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Pioneer planting				
Bolboschoenus fluviatilis	Marsh clubrush	Rush or sedge	✚✚✚	Perennial, but dies back to root system in winter. Spreads by creeping rhizome
Cordyline australis	Cabbage tree (ti)	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters. Can grow on lower slopes along brackish streams.
Juncus maritimus	Sea rush (oioi)	Rush or sedge	✚	Used in saltiest stream stretches at lowest possible level of edge
Leptocarpus similis	Jointed wirerush (wiwi)	Rush or sedge	✚✚✚	Forms clumps that lie down along the stream edge. Spreads slowly with creeping rhizome.
Leptospermum scoparium	Manuka	Shrub	✚✚	Can grow on lower slopes along brackish streams. Very hardy and grows vigorously, but needs to be planted in autumn and must not have roots disturbed when being transplanted.
Metrosideros excelsa	Pohutukawa	Tree	✚	Can grow on lower slopes along brackish streams. Establishes more slowly than other bank stabilising species. Will grow well developed and far-reaching root system.
Muehlenbeckia complexa	Pohuehue (wirevine)	Vine	✚	Grows rapidly. Scrambles over shrubs or forms hummocks on open ground.
Phormium tenax	Flax	Monocot clump former	✚✚	Very hardy with wide environmental tolerances. Unless the alluvial flats are wide, this species should be planted above frequent flood levels as it resists flood waters and can be torn out of bank
Plagianthus divaricatus	Saltmarsh ribbonwood	Shrub	✚✚	Grows in very salty conditions. Necessary for fernbird habitat.
Sophora microphylla	Kowhai	Tree	✚	Can grow on lower saline slopes

2.4 Enhancement Planting

Along many stream banks, there will be existing vegetation. In answering the *Guideline* question 'What's there?', you will have determined, using Field Sheet 1 of the *Guideline,* whether you have sparse native vegetation (enhancement planting type A) or is principally exotic trees (or gorse) (enhancement planting type B). Native species can be planted into both these type A and type B situations.

2.4.1 Native trees & sparse understorey (enhancement planting type A)

Along the banks of many streams, there will be areas of native trees beneath which the native understorey has been eliminated by grazing stock. In order to improve the functioning of the riparian vegetation in these areas, they must be fenced. Natural regeneration of native plants can then be assisted by controlling weeds and pests and allowing quick-growing colonising species to spread naturally from nearby seed sources. Alternatively, the area can be underplanted using appropriate native species. The native plants to be used beneath and existing canopy differ from those grown in the open. This is because the existing vegetation will provide a degree of shelter and will keep the site cooler and moister. The existing vegetation will also block out some of the light, so those species able to cope with lower light levels should be used.

The following table suggests a number of species able to grow in cooler, lower light conditions. Other suitable

Table 10 Species for planting within existing vegetation

The 'amount' indicates the approximate proportions that should be used within the planting unit (✚✚✚ = use plentifully, ✚✚ = use commonly, ✚ = use sparingly). The ultimate heights and environmental tolerances are presented in Appendix III.

Scientific name	Common name	Form	Amount	Comment
Carex dissita	Flat leaved sedge	Rush or sedge	✚✚	Can spread seeds under forest canopy when ground cover weeds have been controlled. Prostrate plant will protect soil surface
Coprosma robusta	Karamu	Shrub	✚✚	Fast-growing shade tolerant species that is capable of growing well beneath a canopy or beneath gorse. Bird-distributed, with abundant autumn berries for birds.
Cordyline australis	Cabbage tree (ti)	Tree	✚	Bird-distributed.
Corynocarpus laevigatus	Karaka	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Dacrycarpus dacrydioides	Kahikatea	Tree	✚	Bird-distributed. The single trunk offers low resistance to flood waters.
Freycinnetia banksii	Kiekie	Vine	✚	Useful for planting above rocky areas as it will drape down and cover rocks, helping to prevent weed growth.
Geniostoma rupestre	Hangehange	Shrub	✚✚	Fast-growing shade tolerant species that is capable of growing well beneath a canopy or beneath gorse.
Hebe stricta var. *stricta*	Koromiko	Shrub	✚✚	Hardy, capable of growing in partially shaded areas.
Macropiper excelsum	Kawakawa	Shrub	✚✚	Bird-distributed.
Melicytus ramiflorus	Mahoe	Tree	✚✚	Best planted in autumn. Establishes more slowly than other bank stabilising species, but is a very common species in young riparian vegetation throughout the region. Very fast growing when it becomes established. Shade tolerant species that is capable of growing well beneath a canopy or beneath gorse. Bird-distributed.
Myrsine australis	Mapou	Tree	✚	Bird-distributed.
Schefflera digitata	Pate	Small tree	✚	Grows rapidly in damp sites, particularly if there is some shade.

species include forest diversity species suggested for the appropriate substrate and section of the stream cross section as described for the various planting units in part 2 of this *Planting Guide.* If the site to be interplanted is particularly dry and bright, then it is better to disregard the presence of the sparse native canopy and use the species outlined in the relevant section of part 2.

2.4.2 Exotic trees or gorse (enhancement planting type B)

In many stretches of stream across the region, the riparian vegetation is dominated by a range of weedy tree species. Unless these trees are blocking the stream, they should be allowed to remain during the initial stages of revegetation. Trees (including gorse) offer a degree of shelter to establishing planted natives and stabilise the banks and prevent large scale erosion. If they are dense, crown lift them to allow light through to the establishing plants beneath. In the case of gorse, small clearings can be established within the thicket for native plants.

The species planted under weedy tree species should be able to tolerate at least semi-shaded conditions, but should ideally be able to manage in the hotter and drier conditions that will be generated when the weedy trees are removed. Appendix III, which contains the tolerances and performance of a variety of plants can be used to help select appropriate plants. Consideration should also be given to the particular substrate and part of the stream bank to be planted. When this has been determined, select the appropriate planting unit from part 2 of this *Planting Guide.*

When the planting has established well, the trees can be ringbarked or drilled and injected with herbicide and left standing if safety is not an issue.

2.4.3 Display gardens (enhancement planting type C)

Where display gardens or amenity plantings exist or are planned, the species used should be those that are able to establish within the planting units that exist at the site. It is unlikely, however, that the species selected and the proportions used will be precisely the same as in a revegetation project undertaken with the aim of simply increasing the extent of native bankside vegetation. The range of plants used in an amenity planting will probably be wider than those given in the tables and profile diagrams for each planting unit as the time and resources available for maintaining the planting are likely to be greater than for a simple revegetation project. These plantings will need to meet certain design criteria. The appearance of a plant in an amenity planting is as important as the ease of establishment and rate of growth of a species in a revegetation project.

When designing a riparian amenity planting, the following ecological functions of the planting should be considered:

- the stabilising of the bank by the planting
- the possible impediment to rapid stormwater flow down the stream
- the shading of the stream and consequent effects on water temperature
- the connection of existing vegetation

2.5 The Management Problems

A number of resource management problems may be encountered at a particular stream. Field sheet 6 in the *Guideline* will help you answer the *Guideline* questions 'What's the problem?'. A number of these problems can be addressed by using particular species in a planting.

The problems that can be addressed by careful design of a planting are:

- Lack of shade, high summer water temperatures, views from and light to living areas (amenity and aesthetic issues)
- Poor bank-side stability
- Nutrient or stormwater contaminants in runoff
- Severe flood flows

The types of species used will depend upon the nature and severity of the problems. For example, species used to improve stability need to be able to survive in an unstable substrate and to establish a stabilising root system. In contrast, species used to shade streams need to grow tall enough to cast a sufficient shadow over the water.

Planting solutions can be derived by adapting the appropriate detailed planting scheme or schemes for the various substrates and parts of the stream bank outlined in the second section of the *Planting Guide.* The performances and tolerances of species given in Appendix III will help you select the appropriate species to use at your site.

2.5.1 Light and shade

The issues of the lack of shade and high summer water temperatures, as well as the provision of views from and light to living areas can all be addressed by carefully selecting species for the planting according to their eventual heights.

It is important to provide shade to the stream and to reduce summer water temperatures. Many species living in streams are unable to survive high water temperatures. High light levels will also stimulate the growth of water plants, such as elodea or oxygen weed. This can choke streams and when the plants die and rot, the oxygen levels in the water will fall and the fish and invertebrates will suffocate.

In order to shade the stream and keep the water cool in summer, it is necessary to make sure that the streamside vegetation is tall enough or broad enough to prevent sunlight from directly reaching the water. The ultimate heights of species are given in the species table (Appendix III).

A decision needs to be made about the degree of shade required. When shade reaches 90%, the groundcover along the edge of the stream gets sparse and the channel becomes wider as the bank edges erode away. However, relatively high levels of shade are sometimes needed to reduce the growth of aquatic weeds and algal blooms. To help determine the issues that are most important and the appropriate levels of shade to target in a planting, the following two paragraphs have been extracted from a NIWA 1999 publication produced for DoC, "Stream Shade: towards a restoration strategy".

'The 1999 NIWA report suggests the following shade targets for different resource management purposes:

- Over 70% to meet shade targets which will reduce water temperature
- 60 - 90% to control algal blooms
- 60 - 90% to make significant changes in invertebrate communities.
- Over 90% to reduce periphyton biomass to the low levels in forest streams
- Less than 70% to maintain stream bank stability

The 1999 report also notes that there are few data on the shade characteristics of trees in riparian zones, but that data from plantation forests indicate:

- 70% shade under 15-20 year old eucalypts spaced 6 metres apart
- 70% shade under 15-20 year old pines spaced 7-14 metres apart
- a maximum shade under eucalypts of 80%
- 90 % shade under pine trees spaced 3.5 - 10 metres apart.'

A very general guide is that native nursery tree species (indicated in Appendix III) would offer approximately 70% shade, while many mature forest species would offer 80% plus.

2.5.2 Flooding

All streams will experience regular flooding following heavy rain. In the *Strategy*, section '1.2 Key Riparian Management Issues in the Region', shows what the development and clearance in the Auckland Region has meant for the degree and severity of flooding.

In areas that regularly flood, plants that offer high resistance to the rapid flows should not be planted and any that exist, particularly willows, should be removed. This is a major factor in the design of plantings for the *stream edge planting unit* and the *flood area planting unit.* Plants such as flax that form rigid clumps increase the roughness coefficient of the stream channel. When these species are well established, their bulk slows down the flow of water and takes up an appreciable amount of space that would otherwise be occupied by the floodwater. In these situations, plantings should be made up mainly of species that will lie down and allow floods to run smoothly over the top of them. Some single trunks species that will develop deep root systems can also be planted. Species that will not interfere severely with the movement or storage of flood water are indicated in the species table (Appendix III).

2.5.3 Bank stability

Erosion is a major problem along streams that have been cleared of vegetation. Usually, planting normal vegetation as described for each planting unit will stabilise minor instability.

The sedge and grass species that lie down during floods appear to greatly reduce the amount of surface erosion from the banks. This is not a function of root development, as even very recent plantings have been found to cause

these reductions. One suggestion is that these plants cause a boundary layer of slower moving water to form immediately at the soil surface.

Some of these species are known to help stabilise the edge of the stream. Rautahi is rhizomatous and has a good ability to spread and hold unstable banks.

Where slumping is a problem, then some trunked species that will develop deep root systems should be planted. These will help with the prevention of slumping and will stabilise the banks. There are a number of native plants that are able to grow reasonably rapidly and form root systems that will help stabilise erosion. The plants that are able to help stabilise unstable ground are indicated in the species table (Appendix III).

In some cases, more rapidly growing plants will be needed. Willows, particularly crack willow *(Salix fragilis)* and grey willow *(Salix cinerea)* should be avoided. These are invasive and develop root systems that block streams. Other species of willow should be treated with caution, as they are increasingly being found invading stream and wetland areas. Poplars are being used successfully for rapid stabilisation of erosion-prone stream banks in the Auckland Region. It should be noted that *Populus alba* is being found to be quite aggressively spreading in places.

2.5.4 Runoff - nutrients and stormwater contaminants

On sites where the runoff of nutrients or stormwater contaminants has been identified as an issue, the buffering and filtering function of the planted vegetation needs to be considered. Dense sedges along the stream bank and flood area will assist with this, but an additional filter of dense grasses along the landward edge of the riparian planting should also be considered. Invasive species, such as kikuyu, should not be encouraged.