DRAFT

PRACTICAL APPLICATIONS DERIVED FROM THREE GROWING SEASONS

ESTUARY REHABILITATION PROJECT
ADOPT A BEACH
JUNE 1989 REPORT

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INTRODUCTION

This report provides practical information on the planting intertidal species common to Puget Sound estuaries. The information is based on several Adopt a Beach projects that have been monitored during two and three monitoring season starting in the spring of 1987. Some of the information is also based on field observations collected by the author and volunteers who have assisted with the project as well as on conversations with scientists specializing in wetlands. Obviously, it is not meant to be a compendium of the state of the art on planting projects in Puget Sound, it merely adds information to this body of knowledge which is in great need of being compiled in a document.

PART ONE: PRACTICAL ASPECTS OF PLANNING AND DEVELOPING A PROJECT is broadly applicable to planting a variety of estuarine species with the exception of eelgrass which is treated separately in PART TWO.

PART TWO: PLANTING BULLRUSH, GRASS AND EELGRASS is based on the experience of planting Scirpus Validus (Softstem Bullrush), Scirpus Maritimus (Maritime Bullrush), Distichlis spicata (Saltgrass) and Zostera marina (eelgrass). The information concerning the first three species is applicable but not verified to some of the other common emergent intertidal species of Puget Sound. The information on eelgrass is obviously limited to the unique growing conditions of that species.

This report begins with a summary of the projects that serve as source information.

DESCRIPTION OF THE PROJECTS THAT SERVED AS SOURCE INFORMATION FOR THIS REPORT

JETTY ISLAND, EVERETT

The goal of this project is to study the colonization by Distichlis spicata of newly created sites that duplicate the tidal elevations and soil salinity levels tolerated by this species. Specifically:

1. To compare the colonization rate of plots planted in different densities.

2. To compare the colonization rate of plots using different transplanting treatments.

3. To compare the colonization rate of plots by observing the interaction between densities and treatments.

Hypotheses:

1. For any single treatment, the greater the density, the more rapid the colonization of plots, as measured by cover.

2. For any single treatment, the less disturbed the root mass of the transplants, the more rapid the colonization of plots, as measured by cover.

3. For any single treatment, the larger the root mass of transplants, the more rapid the colonization of plots, as measured by cover.

PADILLA BAY EELGRASS NURSERY

This project, located in the Padilla Bay eelgrass meadows, compares eelgrass recovery patterns in donor plots and growth patterns in recipient plots, both types of plots being replicates of one another. Without a simple way to quantify the recovery rate of a harvested eelgrass bed, it is difficult to know the extent of damage that harvesting has on the bed. The project also compareS harvesting methods in order to identify the least damaging one. Finally, eelgrass has been planted in pots to see if 1)potted eelgrass grows and 2) it can be transplanted successfully.

SMITH COVE EELGRASS PROJECT, SEATTLE

The Smith Cove eelgrass project involves the establishment of an eelgrass bed in an urban environment using a small high ranging Zosteria marina ecotype (up to +3 ft above mean lower low water) transplanted from a West Seattle beach. The project is located on a tideflat adjoining a slip for deep draft vessels (Pier 91) in the Magnolia section of Seattle.

The project has the following objectives: 1) to improve the low intertidal habitat of a tideflat adjoining a mitigation project of the Port of Seattle and to monitor the effectivess of planted eelgrass in attracting marine organisms, 2) to test the effectiveness of different methods of harvesting and planting (plugs and bare roots, anchored and non anchored plants) and 3) to monitor the dynamics of a planted eelgrass bed.

TERMINAL 108, DUWAMISH WATERWAY, SEATTLE

The goal of this project is to establish a fringe marsh of intertidal species that are compatible with the area, and to observe its trends over several growing seasons. The results will help determine the success of transplanting plugs of Scirpus validus from an adjacent area as a means of propagating this species. The measure of success will be the comparison of plant charactaristics of the project plot with those of the donor site over several growing seasons.

ROUTE 509 MARSH, DUWAMISH WATERWAY, SEATTLE

The goal of this project is to revegetate plots in a damaged area having no vegetation cover with a species indigenous to this marsh (Scirpus maritimus) and to compare the experimentally vegetated plots with adjacent control plots that are allowed to colonize naturally.

PART ONE: PRACTICAL ASPECTS OF PLANNING, DEVELOPING AND MONITORING A PROJECT

Growing intertidal species serves a variety of purposes: mitigation, restoration, creation or enhancement of a habitat. Whatever the purpose, no project should be undertaken without first deciding the functions and values it attemps to create, replace or compensate for. This report assumes that the purpose of the project and its functions and values have been well established and that suitable candidate sites have been selected.

DETERMINING SITE SUITABILITY

Elevation

Tidal elevation is key to the success of emergent plants. There is a tendency to plant to low. A rule of thumb is to plant between the Mean Higher High Water mark (MHHW) and the Mean Lower High Water mark (MLHW). Establishing these elevations is relatively easy: Check the tide tables and observe the site when there is a high tide of 11.5 ft and again when there is a tide of 9.5 ft. Mark the reach for both tides. Plants will usually grow within one vertical foot of these two elevations but not as well. So the acceptable range is four vertical feet and the optimal range is two vertical feet.

Substrates

With the exception of *Salicornia*, intertidal plants do not grow well in rocky, gravelly and hard substrates and combinations thereof. Suitable sites often have these bottoms. The rule of thumb to duplicate the growing conditions of the reference site or of the donor site is poorly applicable here because these areas are usually rich in organic substrates. For information on soil conditions, please refer to PART TWO.

Exposure

It the site is exposed to a long fetch, it will be swept by waves; this is probably why not much is growing there: it is simply too exposed. Intertidal species need to be protected from waves. One of the greatest causes of project failure is wave exposure.

Salinity

It is important to understand intertidal emergent species as fresh water plants that are salt tolerant. The rule of thumb is that plants that are found both in fresh water and salt water will usually tolerate salt concentrations no greater than 5ppm while those that are only found in Puget Sound will tolerate 20ppm.

It is important to record two salinities: surface water salinity and ground water salinity. The later is more crucial since it is the one that irrigates the roots. Donor site salinity should be roughly identical to recipient site salinity. If plants are grown from seed and irrigated with fresh water, plant a few pioneers first to assess their adaptability.

SITE PREPARATION

Soil preparation

As indicated earlier, project site soils are often poor. Fertilizing soils with organic matter has been attempted on one Adopt a Beach project at considerable effort. Glacial till was broken up and mixed with pea gravel and sandy loam. The pea gravel layer helped the sandy loam-silt mixture from washing out. Salicornia planted in this mix thrived more than salicornia planted in broken-up till. It is important to break up hardened substrate and to remove rubble, especially rubble burried in the root zone. Bullrushes smothered by a layer of gravel will be stunted. Bullrushes and grasses will usually find enough nutrients in sand and sand-silt mixtures without the need to add organic soils. Too much silt will cause irrigation problems (see below).

Irrigation

Flat intertidal marshes have elaborate dendritic drainages that prevent the pooling of water. Site preparation for non-sloping sites should include proper drainage. The site cannot be even slighly lower than the surrounding area, otherwise the digging of drainage channels will drain the site poorly. If the site is scalloped, channels should drain the depressions. Standing water that is left unflushed by one or more tide cycles will form salt pannes with salinities as high as 100ppm and hard crusts that barely suitable for such hardy non-natives as Fathen and Brass Buttons. Standing water that is regularly flushed will thrive with microorganisms that decay into thick azoic muds. Plants growing in this environment remain stunted. Highly saturated soils such as those with high silt concentrations (greater than 1/3) are also a poor growing medium. If the boot sinks above the ankle, the soil is too soft.

Sloping

It is best to grade a site at a slope no greater than 1 vertical foot for each six horizontal feet. Sloughing occurs with greater slopes, often resulting in root exposure. See also SITE PROTECTION.

SITE PROTECTION

Browsing

Projects occuring in estuaries, more especially urban ones, will be visited by Canada Geese. These birds are aggressive browsers and will decimate a project rapidly. They are especially fond of grasses and will also chomp on the tender shoots of bullrushes. This is more of a problem betweeen March and June. If geese regulary visit the project, fencing it in its first years will help ensure its survival. The project is especially vulnerable when the plugs are isolated. When the plants start joining the stand is less penetrable.

Debris

Fencing also helps keep out the debris. It can also trap debris washing over the top inside. Leave a gap under the fence to allow small debris to escape. Large debris is the most troublesome for it will roll and crush the vegetation (and even a fence!) A log boom placed outside to deflect the debris off the site.

Wakes

While usually protected from waves, estuary shores are racked by boat wake. Boat wake will scour the substrate, expose roots and wash away plants. There is little that can be done to attenuate this problem other than to place log booms on the periphery of the project.

Sloughing

The best remedy against sloughing is to grade the project site into a gentle slope. Protection from wake and waves will also reduce sloughing. Sloughing that occurs downslope from the plants will expose their roots while sloughing that occurs upslope from the plants will tend to smother them. Upslope sloughing can be reduced by planting transitional intertidal-upland species, such as Deschampsia or Distichlis spicata, to help hold down the soil behind the more emergent species.

DONOR SITES

Careless harvesting can damage a donor site, especially if the demand for plants is large. Techniques for minimizing damage are described in PART TWO. Whenever possible, grow plants from seeds.

PLANTING

Planting with plugs: larger plugs (25cm3) are less likely to wash away or make the plant topple. Planting seedlings in intertidal areas requires some form of temporary anchoring such as biodegradable jute mat or large U shaped anchors that strap down the roots. For more information, please refer to PART TWO.

PART TWO: PLANTING BULLRUSH, GRASS AND EELGRASS

SPECIES: Scirpus validus (Softstem Bullrush)

SOURCE INFORMATION

Terminal 108 fringe marsh construction, Duwamish Waterway, Seattle, Route 509 marsh, Seattle and AAB intertidal species nursery.

GENERAL PROPAGATION CHARACTERISTICS

S. validus is a resilient perenial with a low transplanting mortality rate.

DONOR SITE INFORMATION

Donor Site Selection

As for most intertidal species, it is best to select a donor site with similar characteristics to the recipient site. S. validus is at home in fresh and brackish waters (at least 15 ppm for surface water and 5ppm for ground water). Salt tolerance may be an adaptive trait of ecotypes and may not be universal for the species.

Donor Site Impact

There is no information on donor site recovery since the plants were harvested from an area that was to be dredged. The large, deep and dense roots would leave deep scars, especially if plugs were excavated contiguously.

METHOD OF COLLECTION

In February, large plugs (at least 25 cm3) of adult plants (+/-1m) were dug up at the Terminal 108' site. Cutting through the root mass was very difficult.

ALTERNATIVE PROPAGATION

S. validus is a slow germinator but can be grown from seeds and can be irrigated with fresh water. First year plants survive radical root subdivision.

STORAGE

Terminal 108 plants were stored for two months in sand near the project site. In April they were transplanted to their permanent site. Despite two transplantings during active root growth, first growing season survival was very high.

PLANTING

Plugs were planted in predominantly sand in two or three rows, almost contiguously, and at the +10 ft from Mean Lower Low Water mark. S. validus is also a pioneer species where silt constitutes 25% of the substrates.

ESTABLISHMENT

Comparison with nearby reference site

	1987	1988	1989
Seasonal greening	late	on par	early
Stalk density	lower	lower	on par
Shoot height	shorter	shorter	taller
Flowering density	lower	lower	greater
Rate of die back	earlier	on par	NA

It should be noted that in 1989 the reference site is under stress due to erosion. Nevertheless, the project site has shoots nearing 2 m which is considerably higher than the previous year (1.3m) and taller than for the reference site for any given year.

Cover

1989 is the first year where significant lateral growth is occuring both upslope and downslope from "mother" plugs. Interval planting of plugs would result in very patchy cover for several years unless mixed with compatible co-dominant plants such as typha and Scirpus maritimus.

OTHER INFORMATION

Volunteer plants propagated from seeds grow to 1.5m in their second year. Seedling started in pots and transplanted in the same environment would probably attain a comparable height.

SPECIES: Scirpus maritimus (Maritime Bullrush)

SOURCE INFORMATION
Route 509 marsh, Seattle, AAB intertidal species nursery

GENERAL PROPAGATION CHARACTERISTICS
Scirpus maritimus has a low mortality rate when transplanted to a similar environment.

DONOR SITE INFORMATION
Donor Site Selection
Scirpus maritimus is found in brackish situations. In Seattle, it can be found in places where the surface water and ground water salinity is 17 ppm.

Donor Site Impact
This plant is a deep rooter (20 cm and more). Excavating large open areas creates ponds that are poorly colonized by lateral growth of surrounding vegetation and by volunteers. An alternative is to remove plugs along narrow bands in the pattern of channels flowing toward low areas. The method that was finally adopted at the Route 509 marsh was to extract plugs from the margin of the marsh along a broad front; this method left the least visible damage to the marsh.

METHOD OF COLLECTION
Twenty five cubic centimer and slighly smaller plugs of mature plants (+/- 1m) were dug up in February, March and April, during a period of accelerating root growth but before stalk greening. The month of harvest had no measurable impact on subsequent plant establishment.

ALTERNATIVE PROPAGATION
S. maritimus germinates readily and proliferates in seed bed that are watered with fresh water. First year plants survive well severe root subdivision. Second year plants grown in pots and watered with fresh water grow to about two thirds the height of plants found in the wild and flowering is significant.

STORAGE
No information on storage or multiple transplanting.

PLANTING
Plugs were planted roughly on 75cm centers in soils with a roughly 2/3-1/3 ratio of sand and silt mixed with small gravel and with only traces of visible organic matter. Plants prefer well drained areas to those that are poorly drained. Plants planted above the Mean Higher High Water mark do well as long as the soil at root level remains moist (see below).

ESTABLISHMENT

Comparison with nearby reference site

	1987	1988	1989
Seasonal greening	later	later	later
Stalk density	lower	lower	lower
Shoot height	shorter	shorter	shorter
Flowering density	lower	lower	lower
Rate of die back	NA	later	NA

Cover

Cover is greater in dryer parts of the plots than in areas where the soil is wetter. By the second growing season, plants on 75 cm centers were merging in the dryer areas but plants remained small and isolated in the wetter areas. Furhtermore, the wetter the soil, the greater the mortality between the first and the second season.

OTHER INFORMATION

The cause of poor plant growth in poorly drained areas needs to be researched. In the spring of 1989 the plants in all three plots, except for those on high spots, suffered a reversal: mortality, stunted and late growth. It is possible that a thick layer of azoic mud may be starving roots from oxygen or that the soil is being depleted of nutrients.

SPECIES: Distichlis Spicata

SOURCE INFORMATION
Jetty Island density project, Terminal 108, Route 509 marsh and AAB intertidal species nursery.

GENERAL PROPAGATION CHARACTERISTICS
Distichlis behaves unpredictably. Though it is one of the toughest plants, its propagation from seeds or plugs is not guaranteed.

DONOR SITE INFORMATION
Donor Site Selection
D. spicata tolerates a wide range of salinity and can live upland undistinguishably from other grasses. Plants accustomed to fresh water or to dry environments readily adapt to wet saline soils. At Jetty Island, the donor site was slighly upland from the recipient site and the soil consisted of sand with traces of silt and no visible organic matter.

Donor Site Impact
Plants were removed from rectangles, 1.5 m by 1 m in plugs roughly 25 cm3. By April of the following year, the excavated areas were still quite visible. The impact to the donor site can be lessened by digging out shallower plugs since the root mass is often layered and the upper layer is sufficient to nourish the plant (however, thin plugs may wash away if not anchored).

METHOD OF COLLECTION
Plants grow readily from 25 cm3 plugs either whole or subdivided into 8cm3. To save transporting weight, the sand can be removed from the roots.

ALTERNATIVE PROPAGATION
Transplanting plugs will not necessarily guarantee propagation. Plugs transplanted from Kellogg Island across from terminal 108 in Seattle failed to survive two seasons while potted plants and mats of D. spicata are growing readily at the same location. D. spicata is very tenacious: root fragments that have anchored themselves accidentally have become fully grown plants. Uprooted plugs landing face down send shoots underground that re-emerge as new shoots. Plant propagation from seed can be prolific or fail altogether. D. spicata's rapid growth makes it an excellent candidate for pot or mat propagation whereby seeds are sown on a prepared surface and slices of "lawn" are transplanted to the project site.

STORAGE
There is no experience with storing D. spicata though the resilience of its roots make a it a good candidate for warehousing in moist sand.

PLANTING

The planting at Jetty Island was meant to test the rate of propagation from planting centers at different intervals and for diffrent size plugs. The treatment was as follows:

- •Planting intervals: .75m. 1m and 1.5m
- •Plant size: 25cm3, 8cm3 (with soil matrix), 8cm3 with relatively bare roots.

The planting medium is dredge sand with traces of silt from the Snohomish river.

ESTABLISHMENT

It is still too early to tell which treatment yields the best and fastest cover. Whole plugs tend to grow into larger tufts and smaller planting intervals obviously yield the highest cover. Over what period of time does it all even out? data are insufficient at this time. However, there is significant underground growth radiating from approximately one third of the surviving plugs. As branching continues, it is possible that some of the plots planted at .75m intervals will experience some merging of cover by the end of the second growing season.

A number of small plugs had been torn out from Jetty Island plots. For practical reasons, harvesting heavier plugs will ensure less wash-out. Plots with plants below the Mean Lower High Water have suffered high mortality while those located at Mean Higher High water have shown virtually no mortality between spring 88 and spring 89.

Comparison with nearby reference site

	1987	1988	1989
Seasonal greening			late
Stalk density			NA
Shoot height			on par
Flowering density			NA
Rate of die back			NA

Cover

See Plant Establishment above

OTHER INFORMATION

None

SPECIES: Zostera Marina (Eelgrass)

SOURCE INFORMATION
Padilla Bay nursery project, Smith Cove experimental eelgrass project, Seacrest Park project in Seattle.

GENERAL PROPAGATION CHARACTERISTICS
Z. marina is a difficult species to transplant. Its survival rate is low and its establishment is unpredictable.

DONOR SITE INFORMATION
Donor Site Selection

There are several ecotypes in Puget Sound. Roughly speaking, there is subtidal Z. marina (longer, wider blades) and intertidal Z. marina (shorter thinner blades). To be on the safe side it is best to select the appropriate ecotype for transplanting to the project site.

Donor Site Impact

Intertidal donor site impact is most pronounced when digging up plugs with shovels from mudflats and less pronounced when plugs are removed from sandy substrates. Hand harvesting is least damaging to both mud flats and sandy bottoms.

The Padilla Bay project measured the rate of recovery of donor plots when harvested in different patterns. Harvesting was done by hand. It was assumed that removing eelgrass turions (cluster of blades) contiguously would remove approximately 80% of the root mass. The results one year after harvest are as follows:

- Total removal of cover (2m x 2m plot): lowest recovery
- Checkerboard removal (1m squares): good recovery, some patchiness
- Checkerboard removal (.5m squares): almost total recovery
- 50% thinning (2m x 2m plot): cover indistinguishable from reference plot.

Donor sites where Z. japonica occurs along with Z. marina will yield Z. japonica at the recipient site, particularly if it is at the upper range of the intertidal Z. marina ecotype. Z. japonica is a hardy and prolific propagator that will outcompete Z. marina.

METHOD OF COLLECTION
Plug collection: Plugs crumble when dug up and need to be placed in pots immediately. To prevent dissication of blades (which happens rapidly when the blades no longer rest on a wet surface) the pots need to be sprayed with sea water. This method of removal from a donor site is cumbersome.

Turion collection: Turions can be harvested by hand, making sure to snap root sections no shorter than 12cm. In many cases two turions per root section are harvested.

ALTERNATIVE PROPAGATION

Seed propagation has not been attempted with these projects. Propagation by subdividing potted eelgrass will be attempted in the near future (see STORAGE below).

STORAGE

Short term storage

As mentioned earlier, it is essential to keep the blades wet. When harvesting turions, they should be placed in buckets filled with sea water. Turions can keep several days (turions kept five days are still viable). It is essential to change the water twice a day or to provide continuous flushing, otherwise the rapid decay of epiphites and incidentally harvested organisms will affect the turions.

Long term storage

Harvested eelgrass can grow in pots provided that the storage site conditions duplicate the conditions of the donor site. Pot size and density affects survival rate. Such an experiment at Padilla Bay yielded the following results one year after potting:

- 1 gal. pot planted with 3 turions: 17% survival
- 2 gal. pot planted with 6 turions: 44% survival
- 4 gal. pot planted with 9 turions: 100% survival

PLANTING

All harvesting and planting took place in May (1987 for Smith Cove and 1988 for Padilla Bay and Seacrest Park).

Intertidal planting:

Plug planting

Dig holes deep enough to accept the plug. Ensure that the plant is flushed with the ground; a small rise will affect its proper irrigation. There is no information on the relative success of plug planting. The plug plot at Smith Cove was mostly unsuccessful by the end of the first growing season. Since the treatment was not randomized it is impossible to know whether the cause was due to local conditions, to the dissication of many of the plants during transportation or to the method of harvesting.

Turion planting

To tie or not to tie down: Turions can wash away easily especially in mud flats where the tide rushes in. An easy method of anchoring is to hold down the root with a 10cm piece of coat hanger bent in an "S." The recurved bottom helps anchor the coat hanger. A method that should not be attempted is to plant eelgrass in a trench and hold down the roots with stretched twine then backfill. The twine will float up to the surface, snag the eelgrass and uproot it. Planting the eelgrass roots 5cm deep without anchoring works well in low energy areas. Turion survival at the Smith Cove project was unrelated to anchored vs. non-anchored treatment. In Padilla Bay, where turions were not anchored, there was strong evidence of plants washing away from the recipient plots. Turions where the mud matrix around the roots served as an anchor were dragged outside of the plot in the direction of the flood and had replanted themselves.

Pattern of planting: At Padilla Bay, recipient plots were "mirror images" of the donor plots. Plots were planted in 1m checkerboard pattern, .5m checkerboard pattern and 50% density of the donor plot. Survival one year later does not exceed 20% of the plot and for most plot is less than 5% of the cover. With this experiment it is impossible to say which planting pattern works best.

Site selection

Recipient sites need to be irrigated by seeps at low tide. If the surface is merely wet but not saturated, dissication will occur and the plants will die. A well developed intertidal bed will act as a sponge and retain enough water to irrigate itself. Z. japonica occurs at the upper range of Z. marina. The presence of Z. japonica at a recipient site will cause Z. Japonica to outcompete Z. marina. This may be one of the contributing failures at the Padilla Bay project.

Subtidal planting

Subtidal planting has been attempted in Puget Sound usually with not much success. Adopt a Beach did a subtidal project at the Seacrest Park in Seattle. At this date there is no information on the success of the project.

Cedar boxes 50cm x 50cm x 15 cm were built with biodegradable burlap bottoms, filled with sand and silt from the recipient site and planted with four turions. The boxes were fitted with rebar to serve as anchor and floated to their resting place at -5 and -6 ft from Mean Lower Low Water.

ESTABLISHMENT

The only Adopt a Beach project with sufficient data to observe establishment trends is the Smith Cove project. Unfortunately, the project suffered almost a complete loss during the winter of 1988-1989. The cause of the loss is speculative. A nearby fill project caused heavy siltation to occur and a silt film covered the eelgrass. Sand from the project also drifted in throughout the fall. It is possible that a combination of turbidity and smothering destroyed the plants.

Turions were planted roughly 50cm apart. As noted earlier, anchoring was not a factor in survival. The pattern of growth as observed in the fall of the first growing season, the following spring and the following fall is a s follows:

	OVERALL PLOT COVER (Relative to the previous survey)	AVERAGE DENSITY (Relative to the previous survey)
SPRING 87 (planting)		
FALL 87	Losing	Losing
SPRING 88	Losing	Gaining
FALL 88	Gaining	Gaining

By Fall 88, there were more turions growing than the number planted; but rather than growing throughout the plot, they were growing in three clusters distributed in the east central, south central and southwest section of the plot, leaving large areas with light density or no surviving plants at all. This pattern of growth has implications on plot design: eelgrass planted on an interval pattern will not grow uniformly throughout the plot. To measure plot success on the uniformity of cover would be misleading. It should be expected that eelgrass planted at regular intervals will undergo a decline in cover; but over time, prolific clusters will appear at random.

OTHER INFORMATION

One method of planting eelgrass that should be attempted is to replicate the pattern of natural beds in low density areas. Eelgrass beds are dynamic; eelgrass clusters in those areas seems to migrate along a front and the cover for a fixed area changes from year to year. In transplanting , a boundary should be drawn around the project and eelgrass would be planted in random clusters within the boundary. Endoubtedly some clusters would not survive; but many clusters would contract, expand and migrate within the boundary throughout the seasons.