ADDITIONAL RECOMMENDATIONS TO EXPEDITE SPARTINA ERADICATION IN WILLAPA BAY

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Introduction

Although progress has been made, there are still considerable numbers of plants remaining in areas that have been treated over and over again for several years. A report was submitted in 2009 outlining recommendations to expedite the eradication of Spartina. Many of those suggestions were used by natural resource agencies doing control and significant improvements in overall efficiency were achieved. However, based on results obtain this summer eradication will remain elusive unless control efforts can be improved.

Results:

Treated areas were surveyed from August to October for the number of Spartina plants that were sprayed and had good brown down, sprayed with poor control, or total skipped. This was done at over 25 sites, some smaller than an acre, other as large as 50 acres. Data from some sites were combined if their conditions were similar. Results from 18 locations are shown in Table1. The % miss reflect plants that were either not detected or sprayed in such way to show no sign of color at the time of rating. This later variable is somewhat subjective, as it depended on when it was sprayed and how glyphosate was used in the tank mix. When it was not easy to discern if a plant was successful treated, if was assumed to be false positive (treated). Several patterns are clear from this data.
1) Detection and control is much easier in the mud than salt marsh, where the Spartina canopy can be obscured by other plant species. Across the three sites that were immediate comparable this average out to 23% misses in salt marsh compared to 10% in mud zone.
2) Overall misses for a given site usually decreased with each subsequent spray treatment. For example, total Porter Pt % misses went for 10% in August to 2 % in October. 3) Sites that had a very through systematic grid system were more successful than site that did not lay out and follow a systematic grid. Two WNWR sites where such a grid was used had a total end of the year success rate of 98%., the average end of the year success rate for other site using less rigorous method was only 79%.

Table 1.

Data Assessed	Agency	Site information	total plants	% miss
8-Aug	WSDA	Oysterville, salt marsh North of cannery, salt marsh.	183	25
27-Aug	WNWR	Porter Point, salt marsh and transition zone, 3 recorders plus KP, #'s could be skewed.	783	10
4-Sep	DNR	Leadbetter, within salt marsh, North parking lot toward South.	126	43
4-Sep	DNR	Leadbetter, Mud /transition zone no salt marsh plants within area ' north parking lot toward south,	104	13
4-Sep	WSDA	Leadbetter, South of South parking, slough to sedge meadow around point, salt marsh	223	16
4-Sep	WSDA	Leadbetter, South of South parking, outer mud non salt marsh	202	9
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4-Sep	WSDA	N Nahcotta, Sayce house to Sherwood forest, upper salt marsh. ~ 100' wide 2000 to 3000' long, no seedlings	130	27
11-Sep	WSDA	N Nahcotta, Sayce to Sherwood, salt marsh, recently spray (dye/vs no dye)	172	10
11-Sep	WSDA	PUD substation to Moby Dick upper salt marsh	64	14
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11-Sep	DNR	Leadbetter South parking lot north salt marsh and mud zone	19	36
11-Sep	DNR	Leadbetter disk plots	82	17
27-Sep	WNWR	Porter Point, salt marsh and transition	1676	2
2-Oct	WSDA	Oysterville south to Weilgarts	304	10
16-Oct	WNWR	113th/ Tarlett slough area, South, high marsh and mud/marsh	43	2
16-Oct	WSDA	113th/ Tarlett slough, North, narrow high marsh line only	71	15
28-Oct	DNR	Leadbetter, within salt marsh, North parking lot toward South.	68	55

If the observed search and kill rate probabilities are used (0.63 and 0.75, respectively) on ₣ ground with 20 plants per acre, it will take10 search/spray efforts to reduce the population to 1 plant per acre (or, in equivalent wording, to eliminate all of the plants in 95% of that area), compared to only 3 search/spray efforts if both their success rates are 0.90.

Unless both searching and spraying are significantly improved over current practices, achieving the end game of eradication in the Willapa within the next decade will be unlikely. To help achieve incremental increases in search efficiency and improve spray efficacy, a series of research-based recommendations are provided in the rest of this report.

Table 2.

Site	light/off green Spartina (likely treated, but not lethal) Plant size (~ht) <1’	1' to 2'	>2'	Bright green untreated Spartina Plant size (~ht) <1'	1' to 2’	>2'	total plants	% untreated plants	total plants /100ft	total untreated plants /100 ft	total plants /ac*	total untreated plants /ac*
Porter Pt.	18	21	28	8	21	33	129	50	0.7	0.3	3.0	1.4
Leadbetter between parking lots	41	60	12	27	40	1	181	40	4.8	1.8	20.8	7.8
Leadbetter south of south parking lot	5	7	6	11	14	9	52	70	1.2	0.8	5.4	3.5

*area was based on ~ 100’ width of ease of visibility

Table 2. Reduction in number of search and spray efforts needed to clear Spartina from a site as a function of search and spray effort efficiency.

Mean # of plants/ ac	Number of searches/sprays needed to result in > 95% Spartina-free ground. 63% find rate & 75 % kill rate	70% find rate & 75 % kill rate	63% find rate & 90 % kill rate	70% find rate & 90 % kill rate	90% find rate & 90 % kill rate
5	4	4	3	3	2
10	6	5	5	4	2
20	10	9	8	6	3

Search Strategy Recommendations.

Summary: Eighteen separate surveys were done between August to September along the Peninsula and South part of Willapa Bay to assess the search and spray effort . The % missed plants ranged from 2% to 55%. Eight separate areas were survey in November 2009 representing parts of Willapa Bay treated by Willapa National Wildlife Refuge, DNR, WSDA, WDFW, Pacific County Weed Board, and TNC. Three finding were apparent: 1) spray teams failed to detect and treat significant amounts of Spartina, 2) the more systematic the search the greater the detection success 3) a lot of treated Spartina plants were not dying, and 4) the average Spartina density at the end of 2009 treatment season was still too high to warrant any significant effort to hunt for the last outliers. This is even after going over areas two to four time in a season, and even after using elaborate systemic grid systems.

Improving the probability of finding Spartina.

- Maintain the current grid surveying/spray systems which relies upon an immediate double checking and spraying the subsequent day for skips.

- Conduct fall to late fall surveys to help find missed outliers.
    - One or two people can survey large areas in short time and find ~ 90% of skipped or missed plants. For example, the entire salt marsh at Porter Point Unit could be survey in less than 6-8 hours and find 90% of the plants missed by crews in the summer.
    - Locations where this is most useful are the high salt marshes, sedge meadows and tidal guts where Spartina in the summer is masked by tall vegetation. For example in the summer Spartina hidden along the sedge and rushes meadows is visible only from a few feet away, and in Arrowgrass and Salicornia that distance is only just a little farther. In the fall visibility for those areas is 100' to 200'$^{+}$.
    - If feasible these surveys should include a spray treatment at the same time. However, weather, tides and the NPDES permit may prevent treatment. If plant density is low all plants could be flagged and/or GPSed for treatment next season. If density is too high to warrant flagging, those areas should GPSed.

- Conduct surveys in beyond normal search patterns.
    - The most frequently missed areas are remote tidal guts that extend far up into the marsh, pastures, cross under culvert or roads.
    - The other commonly found site is right along salt marsh –forest edge, under tree canopies.
    - Anther common site are isolated and remote vernal tide pools high up in the salt marsh.

- To achieve a more cost-effective search effort, it will be necessary to begin to maintain a record of all zones/areas were there were zero or near zero detections. For example, it is likely the upper high salt marsh zone of Porter Point will have zero detects. The possible exceptions will be along a few tidal drainage channels. If these areas are essential Spartina free, it is no longer cost effective to take several days with a team of 4 or 5 to resurvey and treat that site. Instead one person could survey and treat / flag the entire area in several hours in October or November. Site that gone through two surveys with no detection in one year should be recorded. These will require a reduced survey effort in 2011.

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- This marsh zone ~ 20- 120' wide with a few exceptions. Most plants found within marsh species, but still a lot in the mud that were skipped or poorly sprayed.
    - Kp walked ¾ mile in 1 hour found ~ 200 plants could have sprayed it with one or two backpacks in 1 or 2 hours. – of course no dry time this time of year. I think I might have missed <10% and left 10 to 15% in the mud therefore – 250 plant = in 9.4 acres.

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It is clear from our data and our analysis of search efforts that the key limiting factor in achieving eradication is the lack of efficacy in finding plants in areas of the bay where they can be easily overlooked, such as in the salt marsh. As long as the probability of finding any given Spartina in these sites is only p=0.63, the timeframe to kill the last Spartina is greatly amplified. Numerous suggestions and strategies are provided that can be used by resource agencies conducting control programs to improve the odds of finding 95% or more of the plants in fewer searches.

1) Search strategy will obviously vary by site type. Spartina on open mudflats are highly visible and are relatively easy to find compared to Spartina on the tidal salt marshes. Spartina on the mudflats usually develop later than those in the marsh. This means a search and spray effort would be much more effective if it was delayed until later in the season, after the initial higher marsh sites have been searched and sprayed. Since mudflats are mainly accessed by airboats or tracked vehicles, grid patterns are somewhat problematic. This means that there will likely be a problem of skipped sections and plants as machines go from one infestation to another. One possible means to minimize skips and help with the find efficiency is to have a dedicated spotter with binoculars, who is on constant vigilance and assures that the search is systematic.

2) Spartina in the tidal marsh or marsh fringe are more difficult to see and thus the search process should be much more systematic. Observations made of state and federal agencies' teams spraying in various locations throughout various Willapa sites have revealed a consistent pattern. After seeing and spraying a plant, applicators are normally distracted from their search-spray grid/transect paths. As a consequence, they veer off along another tangent and miss plants that were in their "assigned" search paths. This was particularly noted when 1 or 2 applicators were assigned to cover a large site and they walked zig-zag through the site looking for Spartina. A recommendation to improve the search pattern in salt marshes would be for 3 to 5 applicators to walk 5', 10' or 20' abreast as they transverse through a site along a specific grid line. The exact grid pattern will vary by site, as some sections of the bay have very narrow salt marshes, where a two-person grid 10' apart would suffice. Other parts of the bay have marshes ¼ to ½ mile wide and will require multiple passes with a crew spaced 5' to 20' apart.

3) Search/spray patterns tended to be habituated. Consequently, the same plants are missed year after year. To minimize this concern, searches should be as independent from any previous search pattern as is practical. That is, search and spray events should be conducted so that searchers use "new eyes" and are not influenced by the footprints, browned-down plants, or their own previous search patterns, nor are they channeled in the same way during every search by topography or other factors. More specifically, agencies should a) rotate spray teams that are used to treat each of the sites (i.e. – not have the same applicators always spraying the same site year after year), and b) alternate direction of travel through a zone (north to south with east to west). It is also important that features of the topography – channels, logs, easy walking, and difficult walking – not be allowed to subtly channel all search teams over the same paths.

4) There should be effective feedback for all spray crews to tell them how efficient their search/spray effort was on any given day or site. In other words, a crew should get feedback on what percent of the plants they are missing and if there is any particular crew member who is sloppy in his/her search effort. This will enable them to learn how to best improve their search effort efficacy. This is difficult to do after the fact. Following browndown (2-4 weeks), it is next to impossible to distinguish new Spartina plants that may have sprouted, or sprayed ones that didn't die, and which crew member(s) were missing most plants along a grid. It is recommended that immediately following a spray effort a subsequent pass be made by a crew to flag any Spartina plant that lacked spray dye or had poor coverage of dye over the entire canopy. This can be done after the tide is no longer suitable for spraying, yet still low enough to find Spartina. White or red 18" or 24" metal flags work excellently for this. A cleanup crew can be used on the subsequent day to treat all skipped plants and pick up the flags. For feedback/training purposes it would be important to maintain some level of records on sprayed/skipped plants. This should include what crew member was spraying what section of the grid, if certain sections of the grid were having a lot more flagged Spartina than other sections, if there are particular sites which are more prone to skips, and if the ratio of spray to skipped plants is reducing over time. These results/patterns will help spray bosses re-educate, re-assign or remove ineffective crew members. The results can also be used to help develop more effective spray patterns and grids. For example if a 4-person spray crew is spaced ~25' apart along a grid and is consistently getting lots of skipped plants, then they could shorten their spacing to 15' along a grid and see if that reduced skipping. This type of a post-treatment flag method doesn't have to be repeated at all sites and times, but should be done at least once or twice at the beginning of the spray season.

5) If the above post-treatment flagging is not practical, other options would be to have a second search/spray crew follow the search/spray zone of the first crew by 15 to 30 minutes. Their purpose would be to spray any skips that were found. These follow-up searches "count," in the sense of Table 2, toward the total numbers of searches needed to clear 95% of the ground of Spartina.

6) Grid patterns are not applicable to all sites. Small, but deep, tidal drainage often dissects a longitudinal search grid and runs 1000' up into the shoreline. During the intensity of the spray effort, these sites are the ones most frequently overlooked year after year by crews. The post-spray search crews should be particularly mindful and diligent in looking for these sites. They should GPS any drainage with skipped Spartina, and not rely on flagging skipped plants in these sites. A classic example of this situation occurred in 2008. An oyster grower found a large clone, 1000' up an obscure minuscule drainage system that jetted into mowed pasture south of Oysterville. This clone had never been observed in the past 10 years. This clone would have only been found if a crew member was mindful enough to follow every tiny drainage channel to its origins.

7) Despite the best attention of a crew, they may or may not cover their entire assigned sites before heading off to another location. There is no guarantee that all sites have been searched and treated. One possible way to avoid major foul-ups is for each applicator to have their own GPS system and have it set on breadcrumbs or tracklog. These tracks could all be downloaded weekly, compiled and skips in section noted for follow-up.

8) Spray teams would be more effective in the long run if they spent more time being slow, deliberate and very zealous in finding and treating as many plants at a site as possible, as opposed to moving routinely through a zone to get done. The emphasis should be on thoroughness, not speed.

9) Search and spray efforts in difficult-to-observe areas like salt marshes should be done to correspond to times/seasons when Spartina is most visible. Search sequences during May and June in the salt marsh will be less successful than sessions in July to September, when plants are bigger. The effect is to improve the probability of plant detection, which ultimately reduces the number of searches needed.

10) Each site needs to be visited three or more times per season. A site no longer has to be visited that year if no untreated plants are found during *each* of three *consecutive* searches. For any site in which untreated plants are found, the search sequence must be reset to zero and three more visits should be employed. In other words, *three consecutive searches, each of which reveals zero untreated plants*, is the condition for ending searches of any plot for that season. Using this protocol, search agencies may eventually be able to free up searching in some sites within a given year and focus manpower in other still-infested areas.

The benefit of multiple searches in a season cannot be over-emphasized. If a strategy is used to stop searching after the first occasion upon which no plants are found, it will take 18 growing seasons to eradicate Spartina. If there are two or three consecutive searches in a season with zero plants found per search, it will only take 3+ or 2+ growing seasons respectively to eradicate Spartina.

Spray Strategy Recommendations.

- Based on our November surveys, some sites had up to 60% of plants with off-green foliage color. These plants had been detected and sprayed earlier in the season. Although making an inference between canopy color and likelihood of plant death is somewhat subjective, the kill rate on any plant that is off-green but has not shown significant herbicide brown down by November, is likely to be low. Thus additional fine tuning of the spray effort is required.
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- is unlikely to be not likely this strongly suggests that ing they . These plants If 40 to , detected in November had been treated, but were unlikely to be completely dead inearlier treatedThe effectiveness of a search, find and spray program to eradicate the remaining Spartina in Willapa Bay is greatly compromised if treated plants are not killed. Numerous observations year after year indicate that Spartina control is often less than perfect. Numerous suggestions and strategies are provided that can be used by resource agencies conducting control programs to improve the odds of control to 95% or greater.

1) With so few acres left to spray, the cost of herbicide is no longer a limiting factor for the Spartina control effort. The low-volume spot treatment label for Habitat states that 0.5 to 5% v/v tank mix can be used, as long as the label rate of 6 pt/ac is not

violated. The amount of product taken up by the plant into the root system is the limiting factor for efficacy; thus a tank mix with >1 % of Habitat would provide better control in situations where efficacy is problematic , such as small regrowth, short dry time, or a dirty canopy. We don't have data to be able to differentiate the difference in efficacy between 1, 2 or 5% Habitat on regrowth. Based on much earlier trials, however, there are major differences in efficacy between 0.5 and 1%. In addition, data from the San Francisco Spartina program has indicate a much better control of Spartina in short dry time locations using a 3% imazapyr @ 25 gpa spray volume. These factors strongly suggest an increase in tank mix ratio for backpack treatments would be appropriate. The recommended ratio will be contingent upon spray volume used by the applicators. The lower the spray volume the higher the recommended ratio of imazapyr. Calibration training session with applicators should be standard training protocol. Two methods are advised: 1) # oz to spray $1/128^{th}$ of an acre = gpa or 2) # seconds to spray a 1, 2, 3 or $4ft^2$ with an adjustable cone nozzle ~= 172, 86, 58 or 43 gpa, respectively. Low-end to high-end range for tank mixes based on spray volume and type of Spartina treated should be 1 to 3% Habitat, 3 to 5 % glyphosate and 1% surfactant. For all sites where the majority of the Spartina has been compromised, the percentage of Habitat in the tank mix should be increased to the higher rate. A compromised site is one where plant vigor is poor and the canopy is sparse and weak, the leaves are dirty or dry time will be <5 hours. More detail is provided in table 3. Enough dye should be added to allow for easy spotting of treated plants.

2) For clean-up spot treatment, high pressure spray equipment is overkill and greatly increases the amount of product used. The minimum trigger time for a quick on/off with a high pressure gun to small plants translates to >500 gpa spray volume. Use of backpacks and low pressure spray units should be considered for all final clean up operations.

3) Applicators should be sure their spray is uniform across all sides of the canopy. Failure to control is frequently an issue of partial coverage.

4) The optimal window for timing spray applications should be after all the regrowth has occurred and the plant has adequate canopy to take up enough spray to kill the entire root system. Too early an application of imazapyr can easily compromise efficacy, and only suppress and weaken the plant, making it even more difficult to control in subsequent years. Research on control of woody perennials with imazapyr has documented that continued annual spraying of weakened plants is ineffective and a year of recovery without spraying is needed before the plant can be treated and killed. A similar situation is likely to occur with weakened, partially dead Spartina. It greatly complicates a spray program to selectively not spray weak plants. Furthermore it is likely beyond the ability of most crews to distinguish previously sprayed weak plants vs. normal healthy plants with late growth. For sites where all the plants in the area have been treated in the previous year and nothing is likely to go to seed, it would be prudent to wait as late in the season as possible before spraying. This would give previously sprayed, weakened but still alive plants time to recover and grow before re-treatment. This could be as late as mid-September. Those sites should then be flagged for missed plants on the day of treatment and retreated the following day to assure no plants are totally skipped for the year. Because most sites in Willapa will be a mix of untreated and treated plants, the above strategy might not

be appropriate for 2009 and could be delayed until 2010. In contrast to these sites where later treatment might be most appropriate, some sites high in the tidal zone are likely to have large enough plants to spray by late May. It could be feasible during warm years to start spraying these sites by early to mid-June.

5) The most critical sites and plants to focus a spray treatment on are those that have the potential to go to seed. Any plant in the second year of growth can flower and produce seed. Any site with scattered large or medium size clones that went untreated last year needs to be the first focus for a spray crew, after which all other sites could be treated. In 2009 it is unlikely that any plants will be seedlings; thus every plant could potentially flower. How real is the threat of seed production from the residual Spartina plants in Willapa Bay? Based on our data in 2008, it is a minor threat. Isolated plants/clones do not appear to produce many, if any, viable seeds. This, however, could have been an anomaly due to the cool growing season in 2008. Any site with a large infestation of previously untreated Spartina should still be the first and primary focus of the 2009 control effort.

6) There are three basic Spartina habitat zones, low tidal mud, mid to upper tidal mud, and the salt marsh. For the zone with longer dry times, the treatment plan to achieve sufficient dry time is fairly intuitive, provided shorter plant heights are accommodated. The areas low in the tidal zone with the shortest dry time is the most problematic. There is only one tide window in 2009, 7/20/09 to 7/25/09, that would allow for adequate dry time on short plants on lower elevation intertidal mudflats. A higher concentration of imazapyr should be used on these sites and all crews should be focused on those areas during that time period.

7) October has been traditionally too late in the spray season to get good efficacy as fall storms compromise the canopy quality. This is especially true for areas in the mudflats or in the transition zone with the salt marsh. Good efficacy can be obtained, however, as long the canopy is clean and hasn't been knocked down or has eelgrass on it. In addition the native salt marsh canopy senesces in the fall, providing excellent visibility of Spartina in the high marsh tidal guts. A search/spray effort should be conducted during this time in as many of the upper marsh tidal guts as possible.

8) Small Spartina plants, this year's or last year's seedlings, are easily killed with herbicide. But, as mentioned before, plants that are small because they have been herbicide-stunted are difficult to control. Differentiating between these plant types may be difficult. Applicators should be trained to distinguish the difference, and leave plants that are stunted for a later treatment.

9) Mechanical treatments that damage intact plants and reduce the integrity of the root system could possibly make subsequent control with herbicide more difficult. There is no direct data on Spartina indicating that this true. For other rhizomatous species however, this has been found to be the case. On some sites with a lot of bird use and tall dead stubble, disking, tilling, or crushing of Spartina will provide a small increase in shorebird usage in the year following treatment. This, however, has not been the case if there is little stubble remaining or if there is plenty of open terrain already present. These treatments also have not been shown to accelerate restoration of the sites back to their original bathymetry. Based on the chance that mechanical

treatment of the ground could compromise efficacy, or slow the time frame of eradication, such treatments are not worth the short-term benefits they may provide to shorebirds.

10) Tables 3 and 4 summarize treatment window and herbicide ratios for different situations.

Table 3. Herbicide tank mix ratios recommended for different Spartina plants and sites*.

Plant type /site	Tank mix ratio (% v/v) of Habitat:Rodeo:Surfactant
Spartina likely to go to seed	1:3:1*
Spartina low in the mudflat	1.5 to 2:3:1*
Spartina high in the salt marsh	1:3:1*
Weak, stunted, previously treated plants	1.5 to 2:3:1*
All remaining small Spartina plants/clones	1:3:1*
Untreated meadows	3.7:10:0.25**

*For all spot treatments these value assume 100 gpa low pressure application. However, if you are using a lower gpa (30 to 50) then the ratio of imazapyr and glyphosate in the mixture should be adjusted upwards. A 3:5:1 for example would be recommend to very difficult to control Spartina.
** For any large untreated meadow use a low volume boom sprayer @ 20 gpa

Table 4. Suggested treatment windows for different type of Spartina plants/sites.

Plant type/site	Treatment window				
	June	July	August	September	October
Spartina likely to go to seed		These should be a spray priority; at least two search and spray events should be done at sites which went to seed in 2008.			
Spartina low in the mudflat		Best or only window to treat is 7/20/09 to 7/25/09			
Spartina high in the salt marsh	First to spray since it will be tallest first.				Last to spray since most visible and maybe only plants with good canopy

					left
Weak, stunted, previously treated plants			Continued re-treatment will only stunt them again. Wait until plants are at least 16” to 20” high before treating.		
All remaining Spartina		Plants should ideally be at least 12 to 20” high before treatment.			

References:
Patten, K. & D. Milne. 2009. Willapa Bay Spartina seed production and eradication models for the upper tidal flats and salt marshes. 2008 Progress Report to the USFW – Willapa Wildlife Refuge.

Patten, K. & C. O’Casey 2009. Shorebird usage in Willapa Bay in response to Spartina control efforts. 2008 Progress Report to the USFW – Willapa Wildlife Refuge.

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11-Sep	WSDA	Oysterville canary to the North, upper salt marsh only	16	274
11-Sep	DNR	Leadbetter South parking lot north upper salt marsh only	88	8
11-Sep	DNR	Leadbetter South parking lot north in mud (east of marsh)	9	11
11-Sep	DNR	Lead better disk plots	17	82
27-Sep	WNWR	Porter Point, salt marsh and transition	2	1676
2-Oct	WSDA	Oysterville south to Weilgarts	10	304
16-Oct	WNWR	113th Tarlett slough area South, high marsh and mud/marsh	2	43
16-Oct	WSDA	133th Tarlett slough parking lot North, narrow high marsh line only	15	71

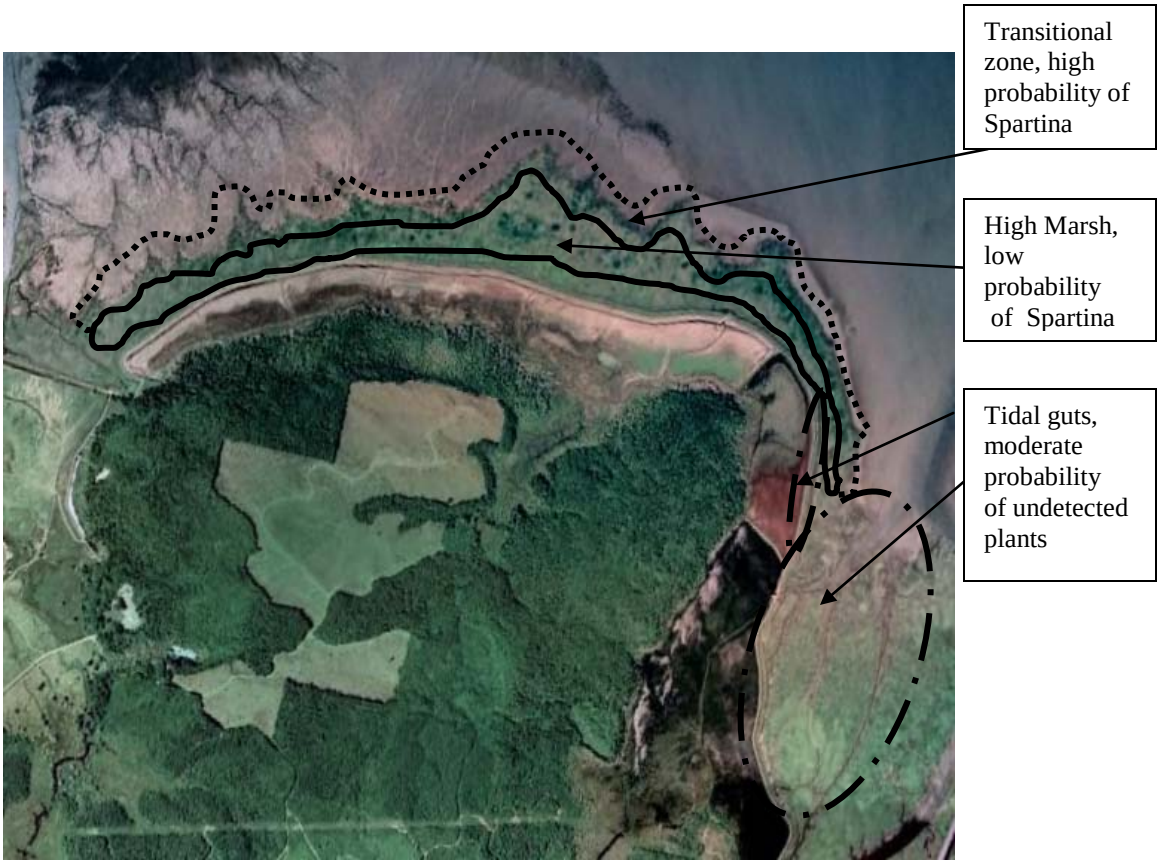

Figure . Three Spartina zone at Pointer Point, with different strategies to achieve eradication.