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SHOREBIRD USE OF *SPARTINA*-AFFECTED TIDELANDS – CAN WE ACHIEVE FUNCTIONAL HABITAT POST-CONTROL?

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Introduction

Spartina has colonized and eliminated much of the upper part of the wide expansive intertidal mudflats of Willapa Bay. Species most threatened by *Spartina* are likely to be the thirty species of shorebirds that rely upon Willapa Bay's 47,000 acres of tideland for food and shelter during annual migrations to and from the Arctic. Much of the most-preferred shorebird habitat of Willapa Bay, sheltered upper tidal mudflats in the south part of the bay, has been displaced by *Spartina*. Peak winter and spring shorebird usage in sections of the bay has declined over 60% in the past decade as *Spartina* meadows have replaced the tidal mudflats (Jaques 2002). Census studies on shorebird abundance in Willapa Bay in 1991-1995, prior to the major increase in *Spartina* growth, found that 44% of the total bird usage was within two areas, the Bear River/Lewis Unit – South Willapa Bay region and the Willapa River area (Buchanan and Evenson 1997). These two areas have become almost contiguous *Spartina* meadows. Because of the loss of habitat caused by *Spartina*, the Audubon Society has recently listed Willapa Bay as the second most endangered shorebird habitat in the United States (Audubon 2004).

The ongoing chemical and mechanical control effort is the first step in recovering that habitat. The ultimate goal of a control effort should not be limited to control, but also needs to consider restoration of the affected habitat for maximal ecological value. Unfortunately, little information exists to date on how the numerous chemical and mechanical control methods being used to manage *Spartina* have expedited habitat restoration. The long-term ecological impact of invasive *Spartina* on shorebirds in England has been recently reviewed by Lacambra et al. 2004. They summarize that a return of shorebirds to English estuaries following *Spartina* removal is not axiomatic. In Washington, where there have been long-term control efforts by various agencies, there have been limited concurrent efforts to record if any particular control method or condition has expedited the restoration of native habitat. The objective of this study was to assess the likelihood and the limiting factors involved in achieving functional habitat of *Spartina*-affected mudflats after control.

Methods

Site information: Direct and indirect assessments of shorebird, waterfowl and birds of prey usage of *Spartina* meadows (treated and untreated) in comparison to bare mudflats were made. These assessments were made for five sites: bare mudflat, tilled *Spartina* meadow, sprayed *Spartina* meadow, spray-mowed *Spartina* meadow and an untreated *Spartina* meadow. Data collected included beak probe density, footprint density, fecal dropping density, visual counts during peak migration in spring 2003 and winter of 2003/2004, and remote monitoring with video cameras in winter/spring 2003. The study site was on Willapa National Wildlife Refuge property at the south end of Willapa Bay. The *Spartina* infestation was 10 to 14 years old and covered over 1000 ha. Treatment sites were adjacent to each other and large enough to be considered ecologically significant units (>60 ha). This part of the bay supported an abundant bird population prior to infestation by *Spartina* (Jacques 2002). Although the sites had similar bathymetry prior to *Spartina* infestation, their current elevations were measured to be >35 cm above the adjacent mudflats. The bare mudflat site is and has been *Spartina*-free. The tilled site has been treated since 2000/2001 with mowing, tilling, and spraying for cleanup. It has been relatively free of *Spartina* since 2002. The sprayed and spray-mowed sites were treated with 2 gallons/acre of Rodeo in summer of 2002 and had follow-up spraying in summer of 2003. The spray-mowed site was mowed to ~ 14 cm level during the spring of 2003 to remove dead stubble and encourage bird usage. The untreated *Spartina* meadow is a large >200 ha meadow at the southwest end of the bay.

Shorebird data: Beak probe density, footprint density, and fecal dropping density (#/0.25m^2) data were collected on May 13, 2003, using five replications per habitat per location, with 5 subsample counts per replication. For each replication, comparative habitats (treatments) were located within 20 feet of each other. Remote monitoring of sites was done using video cameras in winter/spring 2003. A Mitsubishi Time Lapse Security Recorder, Model #HS-1280U, was used to record the black and white image from a Super Circuits PC23C camera w/12mm 1/3" CS TV lens. Power was provided using three 12V Deep Cycle Marine Batteries and a 16W Solar Pane with a DC to AC, 12V, 150 Watt Inverter. Cameras were mounted in weatherproof camera housing on 7 m poles 133 m from the native marsh. The camera focal area for each site varied slightly, ranging from ~90 to 180 m^2. Total bird usage (shorebird and waterfowl) from each tape was recorded every 30 seconds and the data was converted to mean daily flux densities (#/m^2/hour). For shorebirds, daily flux densities were based only on time periods during the day when the tideflats were exposed. The total number of days of complete data collection, from February 18, 2003 to May 14, 2003, ranged from 20 to 40 depending on the site. Visual observation of bird usage in the winter of 2003/04 was done using a single observer. Three plots (1 hectare each) per site were observed for 10 minute intervals using a spotting scope. Observations were timed to coincide with peak usage at each site, just prior to tidal submergence or after tidal withdraw. Observation frequency was at least once a week. Bird species and behavior were noted.

Soil and plant data: Intact cores to the bottom of the root system (80+ cm) were collected by digging a 1 m wide and

deep trench. Standard soil science methodology was used to determine porosity, bulk density, and the core sample composition. By washing the trench wall it was possible to identify all growing point meristems and record their points of origin (depth). The change in depth from the first occurring meristem to the current growing points over the 8 to 10 year period this meadow had been growing was assumed to be a change in tidal elevation resulting from *Spartina*-induced accretion. Data on vascular plant density (#/ m^2) by species were collected in June 2004 from multiple transects from the native marsh line out to 500 m through each treatment site.

Results

Shorebird foraging: Based on visual and remote observation data during the time course of this study, none of the *Spartina* control methods resulted in shorebird usage comparable to the bare mudflats (Figures 1 & 2). Flux density of shorebirds during winter and spring of 2003 was repeatedly higher in the bare mudflat than in the tilled areas, often by orders of magnitude (Figures 1 & 2). Flux densities of shorebirds on the tilled site were higher than the sprayed or spray-mowed site. Only minor differences were observed between these latter two sites. During 480 hours of video recordings, no shorebirds were ever observed at the *Spartina* meadow site. Western sandpipers did not appear to have any real preference over the two sites, while Dunlin showed a higher usage of the bare mudflat. From a behavioral perspective, it appeared that the tilled site had the lowest percentage of skittish feeding and the bare mudflat the lowest percentage of resting (data not shown).

Based on short-term comparisons in shorebird footprints, fecal droppings and beak probe densities, there were major differences in shorebird microsite habitat preferences (Table 1). All types of dead *Spartina* stubble or live *Spartina* stems drastically interfered with shorebird foraging. For three locations within Porter Point, there was almost no evidence of any shorebird usage where there was live *Spartina* growing. The bare mud and dead stubble locations usually displayed high counts of beak and foot prints and fecal droppings. Bare mud usually had twice as much shorebird usage as dead stubble.

Soil and plant data: Spartina meadows rapidly began a transition to native middle to upper salt marsh as soon as the *Spartina* was killed (Figure 3). Within two years of treatment, four salt marsh plant species extended 400 m out from their native marsh habitat. At this particular site, the transition from mudflat to *Spartina* meadow to salt marsh has all occurred with ten years and represents a permanent loss of hundreds of hectares of prime shorebird habitat. In an analysis of soil parameters at this meadow, (data not shown) we have found the dead *Spartina* root mat extends down to 35 cm, with the bulk of the soil volume being comprised of organic matter and pore space. Only 15% of the elevation rise could be accounted for by sediment accretion.

Discussion

Restoring mudflats back to their original form and function will be extremely difficult. Even with tilling and several years of follow-up chemical control, and natural restoration processes occurring over several years, *Spartina*-affected mudflats are far from having shorebird usage comparable to what normally occurred on a bare tidal mudflat. This may be especially true for low tidal energy

Table 1. Shorebird usage of *Spartina* habitat at Porter Point based on footprint, fecal dropping and beak print densities as a function of accessibility.*

General site location	Shorebird access descriptions	Density (#/0.25m^2)**		
		Foot-prints*	Fecal droppings	Beak-prints
Sprayed meadow, 80 m from native marsh; stubble 25-50cm high	Live *Spartina* canopy	0	0	0.8±0.4
	Dead stubble	50±50	0.9±0.4	29±4
	Exposed mudflat	134±11	1.8±0.3	68±10
Edge of sprayed meadow adjacent to bare mudflat, 80 m from native marsh; stubble 25 to 50 cm high	Live *Spartina* canopy	0.2±0.1	0	3±2
	Dead stubble	8±2	6±0.3	13±4
	Exposed mudflat	35±5	0.8±0.2	47±5
Tilled strips in between sprayed *Spartina*, 1000' from native marsh; stubble was mowed at 25 cm height	Dead stubble	87±12	0.5±0.2	25±4
	Exposed mudflat	130±19	1.3±0.3	76±9

*Data collected 5-13-03; 5 replications per habitat per location, with 5 subsample counts per replication. For each replication comparative habitats (treatments) were located with 20 feet of each other.

** mean ± standard error

sites in the southern half of Willapa Bay, where there is traditional high shorebird usage. At these sites, the landscape-scale changes in bathymetry via *Spartina*-induced accretion and root mass accumulation make it unlikely that any restoration effort would be able to bring back the original bathymetry. This is especially true since native marsh is already succeeding in these areas. Once these sites have transitioned to stable salt marshes, there will be little likelihood that they could ever become functional mudflats again. To prevent irreversible loss of prime shorebird habitat, it is therefore absolutely essential to eradicate all existing *Spartina* in these critical sites as quickly as possible.

Can we realistically achieve functional shorebird habitat of *Spartina*-affected tidelands post-control? If the site has undergone major elevation changes, it is likely that it will become a stable salt marsh and achieving shorebird habitat over the long term will be problematic. If the site has not undergone major *Spartina*-induced elevation changes, then habitat restoration is feasible. Restoration may be expedited with a process that breaks up root masses and removes stubble and traces of *Spartina* canopy, such as tilling. This proc-

ess is not inexpensive. Tilling of large *Spartina* meadows is cost-prohibitive, requires very specialized equipment and is very slow (<1 ha/day). Tilling several small 2-3 ha restoration units throughout treated meadows might be a more cost-effective approach to restoring shorebird utilization of sites. It is not clear, however, how much of this tilling effect on shorebirds can be strictly attributed to the actual physical effects of tilling (breaking up the root mass) versus the creation of an open flat smooth surface that is more shorebird friendly. If the latter is the case, then waiting for natural processes to remove residual stubble to create an open surface would be sufficient.

From our data and that of others, it is still unclear what are the most critical factors driving shorebird usage of tideflats post-*Spartina* control – prey density, prey accessibility, predator avoidance behavior, or other variables. Research on changes in prey density post-*Spartina* control has been inconsistent (Lacambra et al. 2004). We found slightly higher benthic infauna on tilled vs. herbicide-treated *Spartina*-affected mudflats, but both were orders of magnitude less than on adjacent unaffected mudflats (data not shown). Based on our data, ease of access to prey is certainly a very significant factor. Removal of live canopy, dead stubble, or thick root mat immediately improves shorebird usage of a site. The presence of stubble and canopy is also likely to affect predator avoidance behavior. Our observational data (not shown) indicated birds of prey exclusively utilized tilled and herbicide-treated *Spartina* meadows rather than open mudflats to hunt shorebirds, even though the latter had orders of magnitude higher shorebird density.

Data from Great Britain on *S. anglica* indicate that shorebird usage of *Spartina*-affected tideflats in English estuaries has taken decades to occur once the *Spartina* has been eradicated or naturally died off (Lacambra et al. 2004). Unless there is a change in sea level or a major subduction event, the prospect of shorebird utilization of the thousands of hectares of *Spartina*-affected mudflats in Willapa Bay could take a similar or even longer time period.

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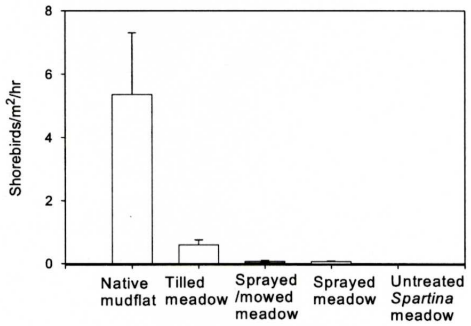

Figure 1. A summary of the comparative use of *Spartina* affected tideflats by shorebirds during the winter/spring migration in 2003 based on foraging flux density data from remote sensing cameras as a function of *Spartina* control method. Bars = Std. Err.

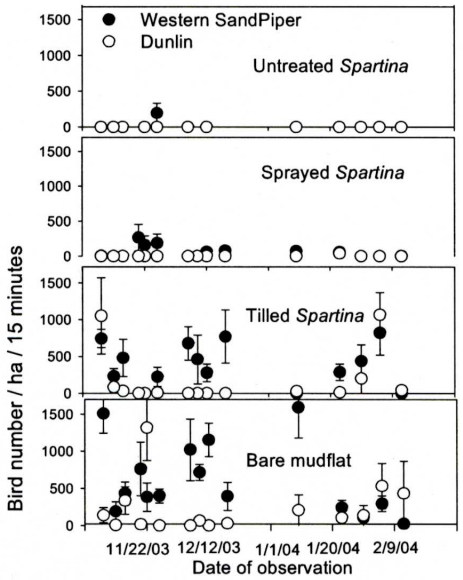

Figure 2. Visual counts of the major shorebird species in Willapa Bay in Winter 03/04 as a function of the *Spartina* control method

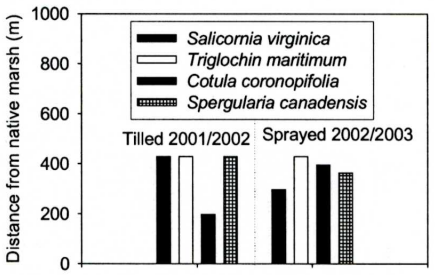

Figure 3. The mean maximum distance from the shoreline that salt marsh species were located after *Spartina* was controlled.
Data were collected June 2004.