Invasive *Limonium* Treatment in the San Francisco Estuary

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CALIFORNIA INVASIVE PLANT COUNCIL SYMPOSIUM

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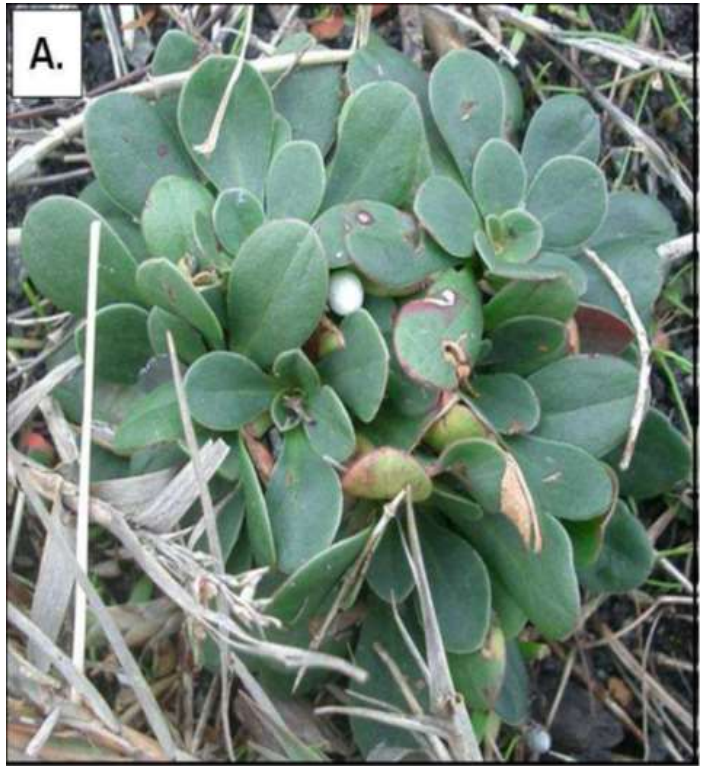
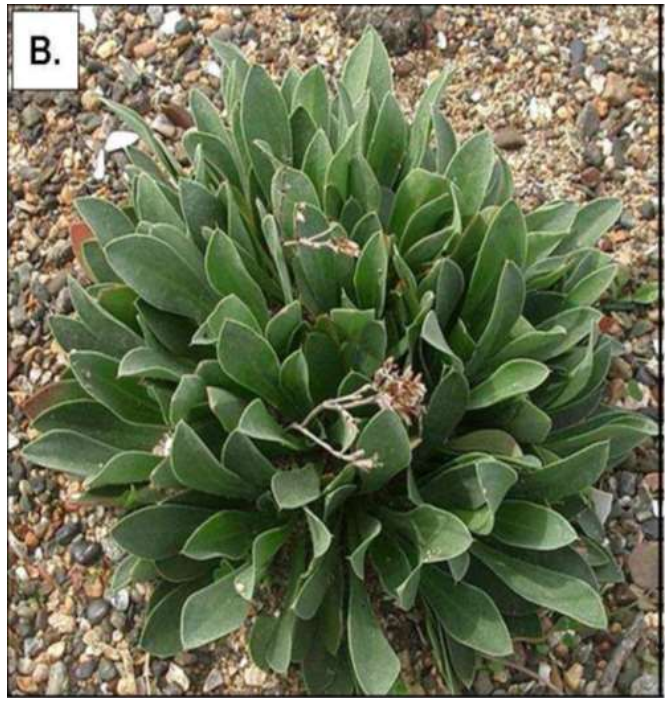
Limonium duriusculum (LIDU; European sea lavender) in the San Francisco Estuary



From Archbald & Boyer 2014

- First discovered in the San Francisco Estuary in 2007 (Strawberry Marsh/Richardson Bay in Marin County)
- Leaves 30-40 mm x 5-9 mm (LxW)
- Basal rosette that produces branching inflorescences (30-50 cm)
- Flowering spikelets with purple corollas (petals)

Limonium ramosissimum (LIRA; Algerian sea lavender) in the San Francisco Estuary



From Archbald & Boyer 2014

- First discovered in the San Francisco Estuary in 2007 (Sanchez Marsh in San Mateo County, just south of SFO)
- Leaves 80-100 mm x 15-20 mm (LxW)
- Basal rosette that produces branching inflorescences (30-50 cm)
- Flowering spikelets with purple corollas (petals)

Limonium species in San Francisco Estuary

Non-native *Limonium ramosissimum* (left) & Native *Limonium californicum* (right)

Ideal Marsh (May 2017) with both plants bolting

Limonium species in San Francisco Estuary

Native *Limonium californicum* playing well with other marsh plants at Ideal Marsh

Limonium species in San Francisco Estuary

Non-native *Limonium ramosissimum* forming a monoculture at Ideal Marsh

This plant may very well have allelopathic properties, to so effectively exclude all other plants

Research into Invasive *Limonium*

- Katharyn Boyer's Lab at San Francisco State University
- Two students studied invasive *Limonium* for their M. S. (Gavin Archbald and Kerstin Kalchmayr)
- Archbald found that in the San Francisco Estuary, they grow most vigorously (and produce the most seed) in the upper high marsh and the estuarine-terrestrial transition zone; vast majority found above Mean High Water (MHW)
- LIRA rosette height, diameter, number of inflorescences per plant, and percent cover all increased significantly with tidal elevation

Research into Invasive *Limonium*

- 15,655 m^2 (1.6 hectares) found throughout the Estuary by 2008
- % cover increased logarithmically with patch size (patches over 200m^2 had greater than 70% cover)
- Most common native marsh plant zones invaded: native *Limonium californicum*, *Jaumea carnosa*, *Frankenia salina* (alkali heath), *Grindelia stricta* (gumplant), saltgrass (*Distichlis spicata*), *and Sarcocornia pacifica* (perennial pickleweed)
- These plants provide valuable habitat to two federally-endangered species, the California Ridgway's rail and salt marsh harvest mouse
- **Replacement of these native plants with carpets of short rosettes of LIRA/LIDU is unlikely to provide native wildlife comparable refugia from predators, especially at high tides when most vulnerable**

Research into Invasive *Limonium*

- Archbald's findings showed LIRA primarily established in **disturbed** high marsh (both natural and human-induced disturbance)
- Seed output of 3,000 to 7,400 seeds per plant
- Estimated **36,000 to 130,000 seeds per m^2**, increasing with elevation
- 11% LIRA spread over one year
- Several documented cases of accidental seeding or planting for restoration also helped spread the invader to new corners of the Estuary
- Genetic studies are needed to evaluate the potential for hybridization

Research into Invasive *Limonium*

- Kerstin Kalchmayr (SFSU Boyer Lab) conducted a follow-up study in 2015
- Mapping showed an increase from 15,110 m^2 in 2008 to 32,002 m^2 in 2015 (113% increase)
- LIRA was also found in an additional 45 locations
- Long-term impacts to soil included an increase in bulk density and reduction in organic matter (potentially negative impact to native marsh structure)

Data-Driven Prioritization of Targets

- With limited funding available, and so many potential target invasive plants, the SFSU research was critical in the **decision to take action**
- LIRA was identified by USFWS as one of three"Highest Concern" plant species in the South San Francisco Bay Weed Management Plan, and is cited as an ideal opportunity for an "early detection/rapid response" treatment approach
- Localized efforts around the Estuary by several groups including CuriOdyssey (Coyote Point), Marin Audubon Society, Friends of Five Creeks, USFWS, CDFW, Save the Bay, Kathy Boyer/SFSU, Bay Area Early Detection Network (BAEDN)

NFWF Grant to Cal-IPC

- In 2015, the California Invasive Plant Council (Cal-IPC) received a two-year grant from National Fish & Wildlife Foundation (NFWF)
- Grant primarily funding pilot treatment of invasive LIRA/LIDU, as well as development of a Marsh Vulnerability Index for San Francisco Bay
- Cal-IPC contracted with Drew Kerr for project management and field supervision of treatment crews, Aquatic Environments Inc. for treatment, and Olofson Environmental for mapping

Setting up Year One of Treatment

- Most of the LIRA/LIDU work around the Estuary had been manual removal, so data on herbicide efficacy was scarce
- Correspondence with all the major entities that conducted chemical treatment, including those in SoCal with more years of data (on LIDU)
- Treatment in the tidal marsh narrows the available herbicide choices

Pest Control Advisor Chris Blodget (CPS) examines LIRA at Sanchez Marsh to inform an herbicide recommendation for Cal-IPC

Herbicide Test Plots

- Tested three herbicide mixtures and compared efficacy to a control
- Two sites: Coyote Point Marina (shown here) and Sanchez Marsh
- 3% imazapyr (Habitat®), 4% glyphosate (Roundup Custom®), and combo of 3% imazapyr + 2% glyphosate.
- Liberate® (lecithin-based product approved for aquatic use)as surfactant at 1%.

Herbicide Test Plots

Herbicide Treatments	*Sanchez Marsh*		*Coyote Point Marina*	
	Pre-treatment (% cover)	**1 MAT (% cover)**	**Pre-treatment (% cover)**	**1 MAT (% cover)**
Plot Group 1				
3% imazapyr, 2% glyphosate	100	5	100	5
4% glyphosate	90	5	95	5
3% imazapyr	85	5	100	50
Control	80	80	65	65
Plot Group 2				
3% imazapyr, 2% glyphosate	95	5	100	5
4% glyphosate	97	10	100	5
3% imazapyr	90	15	100	5
Control	60	80	90	90
Plot Group 3				
3% imazapyr, 2% glyphosate	95	5	100	5
4% glyphosate	97	5	100	35
3% imazapyr	90	5	100	50
Control	85	85	90	90

- Results shown one month after treatment (MAT) as compared with pre-treatment percent cover
- Variation between sites, with efficacy general lower at Coyote Point
- Combo of 3% imazapyr and 2% glyphosate consistently yielded best results, but there was often high efficacy from all three mixes

2016 Pilot *Limonium* Treatment Site Selection

- Selected 12 tidal marsh sites for the two-year pilot treatment under NFWF grant
- Most of these sites had been at least partially mapped by Kerstin Kalchmayr for her M.S. **(key savings for our grant $$)**
- Chose several large infestations near the Estuary epicenter of LIRA (SFO area)
- Included all three of the core study sites from Gavin Archbald's study (Sanchez Marsh, Coyote Point, Seal Slough)
- Included two of the three largest sites in the limited infestation in Marin County (reduce outliers from North Bay & **tap into volunteer network for future**)

Manual LIRA Removal – Corte Madera Ecological Reserve

Manual Removal – Strawberry Marsh

Before & after removal (Spring 2016)

LIDU Invading Rare Plant Population

Carpet of flowering rosettes of LIDU growing amongst the rare native *Chloropyron maritimum* ssp. *palustre* at Strawberry Marsh

Preserved rare *Chloropyron maritimum* ssp. *palustre* (and other natives) after manual LIDU removal

Sanchez Marsh

Fairly typical distribution of LIRA in the Estuary, forming monocultures in the high marsh and estuarine-terrestrial transition zone

Used both backpacks and truck & hose to treat the 5500m^2 at Sanchez, one of the largest infestations in the Estuary

Sanchez Marsh

Monoculture of LIRA (left) &
LIRA growing out of cracks in paved path (below)

Foster City

LIRA on the now-rare oyster shell beach of Foster City at various stages of establishment, from monoculture to new outliers

Ideal Marsh South

Ideal Marsh contains an **atypical distribution**, with LIRA successfully established at lower elevations, imposing a greater impact on the interior of the marsh, reducing habitat along channel banks

Ideal Marsh South

Expansion of LIRA into monocultures along infested channel banks threatens to exclude *Grindelia stricta*, a key habitat feature for endangered Ridgway's rail and salt marsh harvest mice, along with other marsh plants that provide high quality refugia from predators during extreme high tides

Efficacy One Month Post Herbicide Treatment

Greater than 90% efficacy one month post treatment at Sanchez Marsh. Seed development arrested in the highly productive estuarine-terrestrial ecotone

Efficacy One Month Post Herbicide Treatment

Brown LIRA at Oyster Point Marina with abundant **preserved native** *Limonium californicum* flowering to the left

80% efficacy at Coyote Point (a few streaky green plants in the foreground with sub-optimal efficacy)

2016 *Limonium* Treatment Season

- Treatment conducted at 12 tidal marsh sites, 2 with manual treatment
- Total of 24,000m^2 (6 acres) treated in the first year
- First season treatment area equivalent to 160% of the 15,000m^2 Estuary-wide infestation estimated by Archbald in 2008 (additional 9,000m^2)
- Efficacy appeared very high (80-100%) after one month, and throughout the summer, **based on the brown appearance of the plants**.
- BUT invasive plants have a way of surprising you!!

2016 *Limonium* Treatment Season

- When the rains returned in October we got a big surprise. Many of the mature plants were not dead and came back with a vengeance

2016 *Limonium* Treatment Season

- Plus we got the expected flush of seedlings as well
- Remember these little buggers make up to 130,000 seeds per m^2!!!

2016 *Limonium* Treatment Season

- Found that some of the dense LIRA mats would sprout from the side and between dead ones
- Big mature plants, not seedlings

2016 *Limonium* Treatment Season

- Efficacy highly variable, even within sites and tidal elevations
- In general, most sites had a net reduction of around 40-50% after a single treatment in Year 1, with some areas much better.

2016 *Limonium* Treatment Season

- Efficacy tended to be very good at higher elevations
- Positive news for long-term eradication prognosis since Archbald & Boyer found these areas to be the big seed producers

Changes for 2017 *Limonium* Treatment Season

- Started treatment two months earlier than 2016 (mid March vs. late May)
- Earlier start partially to allow for a potential 2nd application after one month (colleagues have found this helpful in SoCal for increasing efficacy on LIDU)
- Allowed us to treat all the sites ahead of flowering to ensure minimal seed production (even if some plants survive they don't flower after application)
- Follow up treatment can look for inflorescences as a guide
- For LIDU and the other work around *Chloropyron maritimum* ssp. *palustre*, we conducted **removal before the annual hemi-parasite emerged**, greatly improving our efficiency AND virtually eliminating impacts to the rare plant

Belmont Slough added in 2017

The addition of Belmont Slough mouth to the pilot in 2017 brings the largest known infestation in the Estuary (over 12,000 m^2 [3 acres]) under treatment. The site is contiguous with the Bair & Greco Island complex of Don Edwards National Wildlife Refuge

Sausalito added in 2017

Sausalito, the 2nd site added to the pilot in 2017, is the largest known infestation in Marin County. This addition means that all known Marin infestations are receiving treatment by either Cal-IPC, Marin Audubon (organized by Jude Stalker), or Marin County Parks & Open Space.

BREAKING NEWS: 2ND NFWF Grant to Cal-IPC for *Limonium*

- October 5, 2017, the California Invasive Plant Council (Cal-IPC) received a 2nd grant from National Fish & Wildlife Foundation (NFWF) for the *Limonium* project
- $200,000 from the San Francisco Bay Estuary Conservation Fund, the maximum award available
- Allows the project to scale-up from treating approximately 50% of the infestation to 90%, including Years 3 & 4 for most of the large and moderate sites

Thank You!

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