# Seedling Emergence from Seed Banks in *Ludwigia hexapetala*-Invaded Wetlands: Implications for Restoration

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## Supplemental Materials

**Table S1**. Vascular plant taxa recorded as emergent seedlings from experimental seed banks (SB) and from extant vegetation (VEG) at the study sites (LGLR = Laguna at Laguna Ranch, LGBC = Laguna at Blucher Creek, LGGC = Laguna at Gravenstein Creek, SRCU = Santa Rosa Creek Upstream) in the Laguna de Santa Rosa Watershed. *Origin status of plants observed are indicated as E= exotic and N = native.

| | | | INVADED | | | | NOT INVADED | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONOCOT | | | LGLR | | LGBC | | LGGC | | SRCU | |
| PLANT SPECIES | FAMILY | E/N* | SB | VEG | SB | VEG | SB | VEG | SB | VEG |
| *Agrostis stolonifera* | POACEAE | E | | | | | | | | |
| *Alisma lanceolatum* | ALISMATACEAE | E | | | | | | | | |
| *Alisma triviale* | ALISMATACEAE | N | | | | | | | | |
| *Bolboschoenus fluviatilis* | CYPERACEAE | N | | | | | | | | |
| *Bolboschoenus maritimus* | CYPERACEAE | N | | | | | | | | |
| *Callitriche heterophylla* | CALLITRICHACEAE | N | | | | | | | | |
| *Crypsis schoenoides* | POACEAE | E | | | | | | | | |
| *Cyperus difformis* | CYPERACEAE | E | | | | | | | | |
| *Cyperus eragrostis* | CYPERACEAE | N | | | | | | | | |
| *Cyperus erythrorhizos* | CYPERACEAE | N | | | | | | | | |
| *Eleocharis acicularis* | CYPERACEAE | N | | | | | | | | |
| *Eleocharis macrostachya* | CYPERACEAE | N | | | | | | | | |
| *Glyceria occidentalis* | POACEAE | N | | | | | | | | |
| *Isolepis cernua* | CYPERACEAE | N | | | | | | | | |
| *Juncus bufonius* | JUNCACEAE | N | | | | | | | | |
| *Juncus effusus* | JUNCACEAE | N | | | | | | | | |
| *Juncus oxymeris* | JUNCACEAE | N | | | | | | | | |
| *Juncus phaeocephalus* | JUNCACEAE | N | | | | | | | | |
| *Juncus xiphioides* | JUNCACEAE | N | | | | | | | | |
| *Leptochloa fusca ssp. fascicularis* | POACEAE | N | | | | | | | | |
| *Leersia orzoides* | POACEAE | N | | | | | | | | |
| *Lolium multiflorum* | POACEAE | E | | | | | | | | |
| *Paspalum distichum* | POACEAE | N | | | | | | | | |
| *Phalaris aquatica* | POACEAE | E | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Phalaris arundinacea* | POACEAE | N | | | | | | | | | | |
| *Polypogon monspeliensis* | POACEAE | E | | | | | | | | | | |
| *Scoenoplectus acutus* | CYPERACEAE | N | | | | | | | | | | |
| *Schoenoplectus americanus* | CYPERACEAE | N | | | | | | | | | | |
| *Schoenoplectus californicus* | CYPERACEAE | N | | | | | | | | | | |
| *Scirpus microcarpus* | CYPERACEAE | N | | | | | | | | | | |
| *Sparganium eurycarpum* | TYPHACEAE | N | | | | | | | | | | |
| *Typha angustifolia* | TYPHACEAE | N | | | | | | | | | | |
| *Typha latifolia* | TYPHACEAE | N | | | | | | | | | | |
| | | | **INVADED** | | | | | | **NOT INVADED** | | | |
| | | | **LGLR** | | **LBBC** | | | | **LGGC** | | **SRCU** | |
| **DICOT PLANT SPECIES** | **FAMILY** | **E/N*** | **SB** | **VEG** | **SB** | **VEG** | | | **SB** | **VEG** | **SB** | **VEG** |
| *Ammania robusta* | LYTHRACEAE | N | | | | | | | | | | |
| *Atriplex prostrata* | CHENOPODIACEAE | E | | | | | | | | | | |
| *Bidens frondosa* | ASTERACEAE | N | | | | | | | | | | |
| *Bidens laevis* | ASTERACEAE | N | | | | | | | | | | |
| *Chamaesyce serpyllifolia* | EUPHORBIACEAE | N | | | | | | | | | | |
| *Convolvulus arvensis* | CONVULVULACEAE | E | | | | | | | | | | |
| *Conyza canadensis* | ASTERACEAE | N | | | | | | | | | | |
| *Crassula aquatica* | CRASSULACEAE | N | | | | | | | | | | |
| *Cuscuta indecora* | CUSCUTACEAE | N | | | | | | | | | | |
| *Cypselea humifusa* | AIZOACEAE | E | | | | | | | | | | |
| *Epilobium ciliatum ssp. ciliatum* | ONAGRACEAE | N | | | | | | | | | | |
| *Epilobium densiflora* | ONAGRACEAE | N | | | | | | | | | | |
| *Eryngium aristulatum* | APIACEAE | N | | | | | | | | | | |
| *Gnapthalium palustre* | ASTERACEAE | N | | | | | | | | | | |
| *Lactuca serriola* | ASTERACEAE | E | | | | | | | | | | |
| *Lepidium latifolium* | BRASSICACEAE | E | | | | | | | | | | |
| *Lotus corniculatus* | FABACEAE | E | | | | | | | | | | |
| ***Ludwigia hexapetala*** | ONAGARACEAE | E | | | | | | | | | | |
| *Ludwigia palustris* | ONAGARACEAE | N | | | | | | | | | | |
| *Ludwigia peploides ssp montevidensis* | ONAGARACEAE | E | | | | | | | | | | |
| *Ludwigia peploides ssp peploides* | ONAGARACEAE | E | | | | | | | | | | |
| *Lythrum hyssopifolia* | LYTHRACEAE | E | | | | | | | | | | |
| *Lythurum salicaria* | LYTHRACEAE | E | | | | | | | | | | |
| *Melilotus alba* | FABACEAE | E | | | | | | | | | | |
| *Mentha pulegium* | LAMIACEAE | E | | | | | | | | | | |
| *Mimulus guttatus* | PHRYMACEAE | N | | | | | | | | | | |
| *Montia fontana* | PORTULACACEAE | N | | | | | | | | | | |
| *Montia linearis* | PORTULACACEAE | N | | | | | | | | | | |
| *Myriophyllum aquaticum* | HALORAGACEAE | E | | | | | | | | | | |
| *Phyla nodiflora* | VERBENACEAE | N | | | | | | | | | | |
| *Helminthotheca echioides (x-Picris)* | ASTERACEAE | E | | | | | | | | | | |
| *Plantago subnuda* | PLANTAGINACEAE | N | | | | | | | | | | |

| | | |
|---|---|---|
| *Persicaria amphibia (x-Polygonum)* | POLYGONACEAE | N |
| *Persicaria hydropiperoides* | POLYGONACEAE | N |
| *Persicaria lapathifolia (xPolygonum)* | POLYGONACEAE | N |
| *Persicaria pensylvanica* | POLYGONACEAE | E |
| *Persicaria punctata* | POLYGONACEAE | N |
| *Polygonum aviculare ssp. depressum* | POLYGONACEAE | E |
| *Rorippa curvisiliqua* | BRASSICACEAE | N |
| *Nasturtium officinale* | BRASSICACEAE | N |
| *Raphansus sativa* | BRASSICACEAE | E |
| *Rorripa nasturtium-aquaticum* | BRASSICACEAE | N |
| *Rorripa palustris* | BRASSICACEAE | N |
| *Rumex crispus* | POLYGONACEAE | E |
| *Salix exigua* | SALICACEAE | N |
| *Sonchus oleraceus* | ASTERACEAE | E |
| *Spergularia rubra* | CARYOPHYLLACEAE | E |
| *Stachys albens* | LAMIACEAE | N |
| *Symphyotrichum subulatum* | ASTERACEAE | N |
| *Urtica dioica* | URTICACEAE | N |
| *Veronica americana* | PLANTAGINACEAE | N |
| *Veronica anagallis-aquatica* | PLANTAGINACEAE | E |
| *Veronica catenata* | PLANTAGINACEAE | E |
| *Veronica peregrina ssp. xalapensis* | PLANTAGINACEAE | N |
| *Xanthium strumarium* | ASTERACEAE | N |

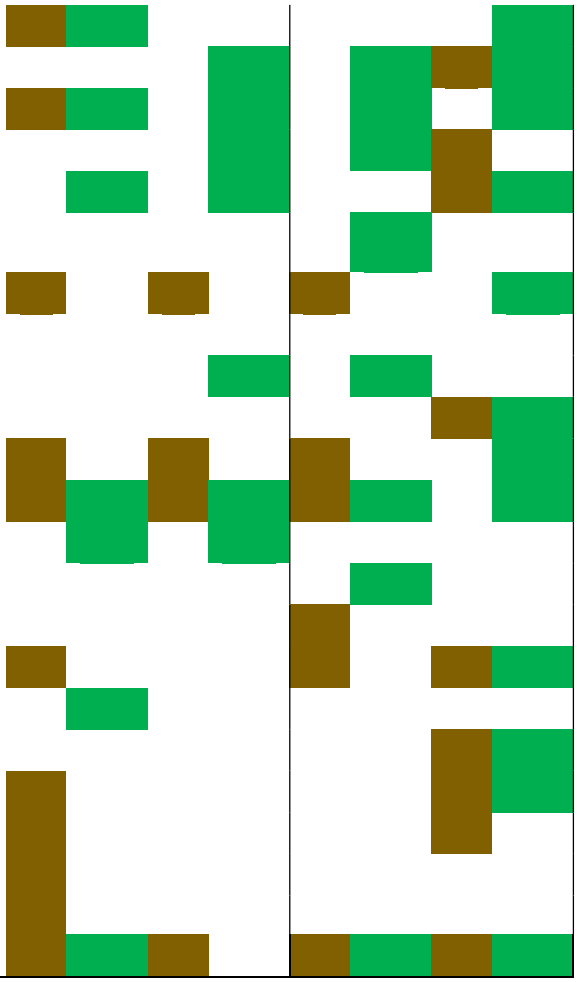

**Table S2**. Total counts of germinants, germinants per kg of soil core sample, total number of plant taxa, exotic and native germinants, and exotic and native plant taxa that emerged as seedlings from experimental seed banks under two hydrology treatments (F = flood inundate; D = Drawdown, Sub-irrigated) from soil seed banks collected at two sites invaded by *L. hexapetala* (LGLR = Laguna de Santa Rosa at Laguna Ranch; LGBC = Laguna de Santa Rosa at Blucher Creek confluence) compared to two nearby sites without *L. hexapetala* (Santa Rosa Creek upstream of Laguna de Santa Rosa confluence; LGGC = Laguna de Santa Rosa at Gravenstein Creek confluence).

| TREATMENT | | | | RESPONSE COUNTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| SITE | HYD | DEP | REP | Total Germinants | Germinants (per kg soil) | TAXA | Exotic Germinants | Native Germinants | Exotic Taxa | Native Taxa |
| SRCU | F | U | 1 | 23 | 63.2 | 5 | 9 | 14 | 1 | 4 |
| SRCU | F | U | 2 | 10 | 27.5 | 3 | 3 | 7 | 1 | 2 |
| SRCU | F | U | 3 | 5 | 13.7 | 2 | 4 | 1 | 1 | 1 |
| SRCU | F | U | 4 | 7 | 19.2 | 2 | 5 | 2 | 1 | 1 |
| SRCU | F | U | 5 | 5 | 13.7 | 2 | 4 | 1 | 1 | 1 |
| SRCU | F | L | 1 | 4 | 9.7 | 3 | 0 | 4 | 0 | 3 |
| SRCU | F | L | 2 | 2 | 4.9 | 1 | 0 | 2 | 0 | 1 |
| SRCU | F | L | 3 | 4 | 9.7 | 1 | 4 | 0 | 1 | 0 |
| SRCU | F | L | 4 | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| SRCU | F | L | 5 | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |
| SRCU | D | U | 1 | 184 | 505.5 | 20 | 19 | 165 | 7 | 13 |
| SRCU | D | U | 2 | 41 | 112.6 | 9 | 2 | 39 | 2 | 7 |
| SRCU | D | U | 3 | 64 | 175.8 | 16 | 3 | 61 | 2 | 14 |
| SRCU | D | U | 4 | 33 | 90.7 | 11 | 10 | 23 | 2 | 9 |
| SRCU | D | U | 5 | 38 | 104.4 | 13 | 16 | 22 | 4 | 9 |
| SRCU | D | L | 1 | 65 | 157.8 | 17 | 15 | 50 | 5 | 12 |
| SRCU | D | L | 2 | 23 | 55.8 | 12 | 1 | 22 | 1 | 11 |
| SRCU | D | L | 3 | 5 | 12.1 | 4 | 0 | 5 | 0 | 4 |
| SRCU | D | L | 4 | 31 | 75.2 | 6 | 0 | 31 | 0 | 6 |
| SRCU | D | L | 5 | 20 | 48.5 | 7 | 6 | 14 | 3 | 4 |
| LGGC | F | U | 1 | 16 | 55.4 | 3 | 4 | 12 | 2 | 1 |
| LGGC | F | U | 2 | 47 | 162.6 | 4 | 35 | 12 | 2 | 2 |
| LGGC | F | U | 3 | 22 | 76.1 | 4 | 7 | 15 | 2 | 2 |
| LGGC | F | U | 4 | 32 | 110.7 | 3 | 11 | 21 | 2 | 1 |
| LGGC | F | U | 5 | 34 | 117.6 | 3 | 17 | 17 | 1 | 2 |
| LGGC | F | L | 1 | 12 | 30.8 | 4 | 5 | 7 | 2 | 2 |
| LGGC | F | L | 2 | 10 | 25.7 | 6 | 3 | 7 | 1 | 5 |
| LGGC | F | L | 3 | 15 | 38.6 | 5 | 2 | 13 | 1 | 4 |
| LGGC | F | L | 4 | 12 | 30.8 | 4 | 5 | 7 | 2 | 2 |
| LGGC | F | L | 5 | 39 | 100.3 | 3 | 14 | 25 | 1 | 2 |
| LGGC | D | U | 1 | 259 | 896.2 | 17 | 43 | 216 | 5 | 12 |
| LGGC | D | U | 2 | 201 | 695.5 | 21 | 108 | 93 | 7 | 14 |
| LGGC | D | U | 3 | 96 | 332.2 | 20 | 47 | 49 | 7 | 13 |
| LGGC | D | U | 4 | 107 | 370.2 | 15 | 31 | 76 | 6 | 9 |
| LGGC | D | U | 5 | 128 | 442.9 | 14 | 80 | 48 | 6 | 8 |
| LGGC | D | L | 1 | 46 | 118.3 | 11 | 18 | 28 | 3 | 8 |
| LGGC | D | L | 2 | 54 | 138.8 | 13 | 18 | 36 | 4 | 9 |
| LGGC | D | L | 3 | 97 | 249.4 | 17 | 48 | 49 | 8 | 9 |
| LGGC | D | L | 4 | 103 | 264.8 | 14 | 27 | 76 | 3 | 11 |
| LGGC | D | L | 5 | 123 | 316.2 | 14 | 41 | 82 | 7 | 7 |
| LGBC | F | U | 1 | 11 | 35.7 | 3 | 2 | 9 | 0 | 3 |
| LGBC | F | U | 2 | 11 | 35.7 | 3 | 5 | 6 | 0 | 3 |
| LGBC | F | U | 3 | 0 | 0.0 | 0 | 0 | 0 | 0 | 0 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| LGBC | F | U | 4 | 1 | 3.2 | 1 | 0 | 1 | 0 | 1 |
| LGBC | F | U | 5 | 6 | 19.5 | 2 | 5 | 1 | 1 | 1 |
| LGBC | F | L | 1 | 23 | 67.8 | 3 | 22 | 1 | 2 | 1 |
| LGBC | F | L | 2 | 9 | 26.5 | 1 | 9 | 0 | 1 | 0 |
| LGBC | F | L | 3 | 1 | 2.9 | 1 | 0 | 1 | 0 | 1 |
| LGBC | F | L | 4 | 5 | 14.7 | 2 | 2 | 3 | 1 | 1 |
| LGBC | F | L | 5 | 8 | 23.6 | 2 | 6 | 2 | 1 | 1 |
| LGBC | D | U | 1 | 38 | 123.4 | 7 | 13 | 25 | 3 | 4 |
| LGBC | D | U | 2 | 98 | 318.2 | 18 | 36 | 62 | 7 | 11 |
| LGBC | D | U | 3 | 38 | 123.4 | 7 | 3 | 35 | 2 | 5 |
| LGBC | D | U | 4 | 61 | 198.1 | 11 | 13 | 48 | 4 | 7 |
| LGBC | D | U | 5 | 33 | 107.1 | 8 | 5 | 28 | 2 | 6 |
| LGBC | D | L | 1 | 84 | 247.8 | 9 | 18 | 66 | 2 | 7 |
| LGBC | D | L | 2 | 41 | 120.9 | 5 | 8 | 33 | 3 | 2 |
| LGBC | D | L | 3 | 11 | 32.4 | 6 | 2 | 9 | 2 | 4 |
| LGBC | D | L | 4 | 119 | 351.0 | 14 | 11 | 108 | 5 | 9 |
| LGBC | D | L | 5 | 36 | 106.2 | 12 | 15 | 21 | 5 | 7 |
| LGLR | F | U | 1 | 12 | 41.4 | 5 | 6 | 6 | 2 | 3 |
| LGLR | F | U | 2 | 12 | 41.4 | 4 | 9 | 3 | 2 | 2 |
| LGLR | F | U | 3 | 3 | 10.3 | 3 | 1 | 2 | 1 | 2 |
| LGLR | F | U | 4 | 20 | 69.0 | 4 | 15 | 5 | 1 | 3 |
| LGLR | F | U | 5 | 19 | 65.5 | 2 | 18 | 1 | 1 | 1 |
| LGLR | F | L | 1 | 4 | 14.3 | 3 | 1 | 3 | 1 | 2 |
| LGLR | F | L | 2 | 3 | 10.7 | 2 | 2 | 1 | 1 | 1 |
| LGLR | F | L | 3 | 4 | 14.3 | 2 | 4 | 0 | 2 | 0 |
| LGLR | F | L | 4 | 7 | 25.0 | 2 | 6 | 1 | 1 | 1 |
| LGLR | F | L | 5 | 14 | 50.0 | 3 | 12 | 2 | 1 | 2 |
| LGLR | D | U | 1 | 189 | 651.7 | 17 | 62 | 127 | 7 | 10 |
| LGLR | D | U | 2 | 442 | 1524.1 | 28 | 225 | 217 | 12 | 16 |
| LGLR | D | U | 3 | 72 | 248.3 | 10 | 7 | 65 | 2 | 8 |
| LGLR | D | U | 4 | 82 | 282.8 | 13 | 15 | 67 | 4 | 9 |
| LGLR | D | U | 5 | 54 | 186.2 | 10 | 16 | 38 | 3 | 7 |
| LGLR | D | L | 1 | 134 | 478.6 | 16 | 36 | 98 | 6 | 10 |
| LGLR | D | L | 2 | 205 | 732.1 | 19 | 71 | 134 | 7 | 12 |
| LGLR | D | L | 3 | 41 | 146.4 | 11 | 13 | 28 | 7 | 4 |
| LGLR | D | L | 4 | 31 | 110.7 | 7 | 8 | 23 | 3 | 4 |
| LGLR | D | L | 5 | 76 | 271.4 | 14 | 32 | 44 | 4 | 10 |

**Figure S3**. Soil physico-chemical characteristics of surface (U) and buried (L) sediment seed bank samples from the Laguna de Santa Rosa. Sites codes for uninvaded sites are: Laguna at Gravenstein Creek (LGGC); Santa Rosa Creek above Laguna (SRCU). Site codes for *L. hexapetala* invaded sites are: Laguna at Laguna Ranch (LGLR); Laguna at Blucher Creek (LGBC). Data points represent means with 95% confidence intervals. Some error bars are too small to be visible.