Buried Alive: Assessing Soil Seed Bank Persistence to Assist in Invasive Species Eradication

Michelle Higashi, Lauren Weisenberger, Julia Lee, Jane Beachy: O´ahu Army Natural Resources Program, Honolulu, Hawai´i

ABSTRACT

Understanding the seed biology of invasive plant species can assist managers in achieving eradication, particularly as it applies to scheduling treatment intervals (in conjunction with plant phenology) and monitoring for recruitment following removal of all target plants. Knowledge of seed bank potential, or how long seeds remain viable when in the ground, is critical to defining eradication for a taxon. Over the last ten years, the O'ahu Army Natural Resources Program (OANRP) collected mature fruits from nine naturalized or incipient invasive species to classify their soil seed bank type. Seeds from each of the species were kept in dark, wet conditions in the laboratory and/or buried in durable bags six inches below ground in the field. Bags and seeds were retrieved and sown at regular intervals to assess viability. As a result, taxa were classified as having transient, short-term persistent, or long-term persistent soil seed banks. This information will assist in developing control strategies and determining eradicability for these taxon, on a species and site level.

BACKGROUND

OANRP mitigates for threats that impact endangered species found in and around Army training areas (Fig. 1). This includes removal of both naturalized and incipient invasive plant species. While habitat restoration is the goal of most weed control efforts, select incipient invasive taxa are targeted for eradication. Determining the persistence of the soil seed of target weeds guides both habitat restoration and eradication efforts, and is critical to identifying if/when eradication of a specific infestation can be achieved. Species persist in the soil seed bank for varying amounts of time (Table 1).

Table 1. Soil Seed Bank Potential Definitions

Soil Seed Bank Type	Seed Viability
Transient	up to 1.5 years
Persistent, Short Term	1.5-5 years
Persistent, Long Term	longer than 5 years

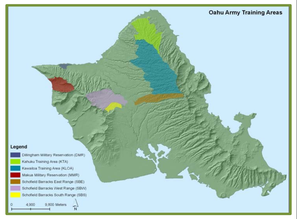


Fig.1. O´ahu Army Training Areas

METHODS

Seeds were opportunistically collected during weed removal activities in OANRP management areas.

Initial Viability Assay: Temperature, water, and light are important external factors affecting seed germination. Imbibition (uptake of water) of seeds is necessary for germination, while the presence of light can be a trigger for certain species. For this study, we considered a seed to have germinated when a radicle (root) and cotyledons formed. A subsample of each collection was sown in Petri dishes of 1% water agar in Percival© seed germination chambers (Fig. 2, exposed to light and moisture; average daily and nightly temperatures to mimic conditions at 2000' elev., northern Wai´anae Mountains).

Fig. 3. (left to right) Collecting *C. odorata* seeds in the field. Installing *S. condensatum* buried seed trial. The *C. setaceus* buried seed trial; located in the taxon's preferred habitat .

Field Trials: Seeds were sealed in polyester fabric bags and buried 6 inches below the soil surface near existing populations (Fig. 3). Buried bags were retrieved at regular intervals.

- **Dark, Buried:** Seeds that had germinated in the buried bags were counted.
- **Light, After Buried:** Intact, non-germinated seeds were sown on agar and put in the growth chambers, exposed to light, and all germinating seeds were counted (similar methods as Initial Viability Assay).

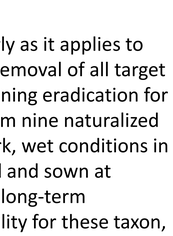
Lab Trials: Seeds were sown on agar in Petri dishes, wrapped in one layer of plastic wrap, followed by two layers of aluminum foil to keep light out. Seeds had enough moisture to remain imbibed (absorbed necessary amount of water to allow for germination) throughout dark treatment. Dishes were placed in germination chambers and retrieved at regular intervals.

- **Dark, Imbibed**: Seeds that had germinated in the dark were counted.
- **Light, After Imbibed**: Petri dishes were unwrapped and intact, non-germinated seeds were sown on agar and kept in the growth chambers, exposed to light, and all germinating seeds were counted.

Results from these germination trials (Fig. 5) were interpreted to classify type of soil seed bank. Species with seeds that germinate in the absence of light (Dark, Imbibed treatment (Lab Trial)) were classified as transient or not likely to form persistent seed banks. Species with seeds where viability declined (or was projected to decline) to ~0% by approx. 5 years (or projected) when exposed to light upon removing from buried bag or dark/imbibed treatment were classified as persistent, short-term. Seeds with little decline in viability after 5 years were classified as persistent, long-term (Table 2).

Fig.4. Seeds of *E. stipoides* that germinated during the Dark/Imbibed Lab treatment.

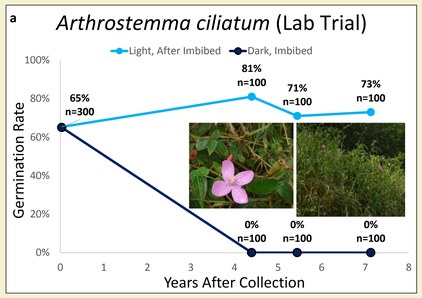
Fig. 2. Seeds of *E. stipioides* germinating in an initial viability assay.

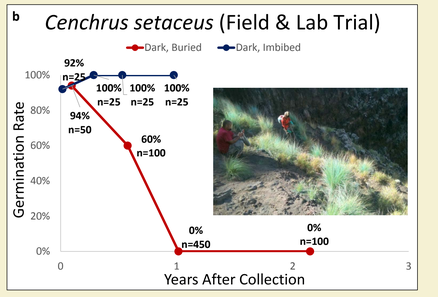


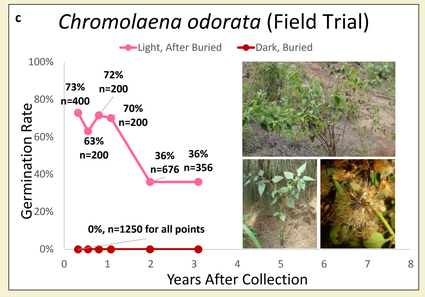
References:

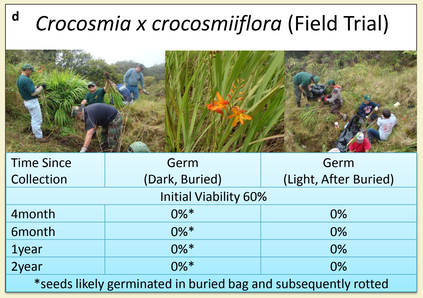
- Hawaii-Pacific Weed Risk Assessment. 2015. www.hpwra.org
- Walck et al. 2005. Defining transient and persistent seed banks in species with pronounced seasonal dormancy and germination patterns. Seed Science Research **15**: 189-196

RESULTS - SOIL SEED BANK POTENTIAL



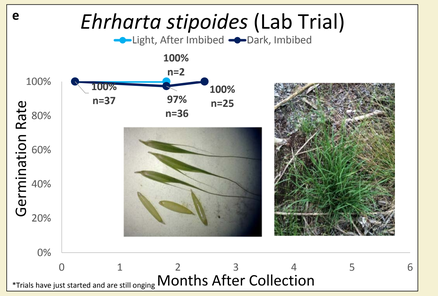


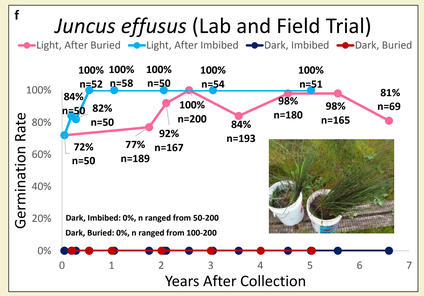


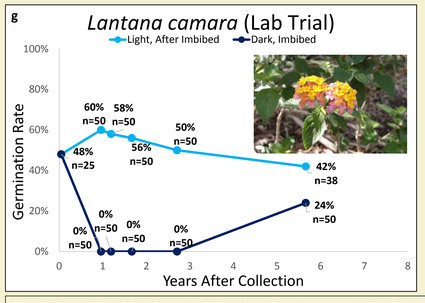


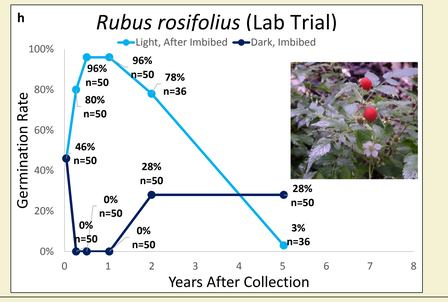
Time Since Collection	Germ (Dark, Buried)	Germ (Light, After Buried)
Initial Viability 60%		
4month	0%*	0%
6month	0%*	0%
1year	0%*	0%
2year	0%*	0%

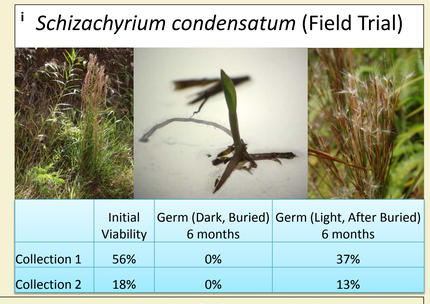
*seeds likely germinated in buried bag and subsequently rotted











	Initial Viability	Germ (Dark, Buried) 6 months	Germ (Light, After Buried) 6 months
Collection 1	56%	0%	37%
Collection 2	18%	0%	13%

Fig. 5. Seed Viability Graphs & Tables. Graphs a-c, e-h indicate Field Trial, Lab Trial, or both (see methods for definitions). For graphs a, b, and e-h navy blue lines indicate germination that took place while seeds were in the dark, imbibed treatment (Lab Trial); turquoise lines (not in b) indicate germination of those seeds upon exposure to light (unwrapped). For graphs b, c, and f, red lines indicate germination that took place while seeds were buried (Field Trial), and pink lines indicate germination of those seeds upon exposure to light (unburied). Each navy blue or red point on a graph represents the germination in the dark at one interval (either 2 bags of seeds or 1 dish) that was exposed to light (corresponding turquoise or pink point at same time (x-axis) interval).

Table 2. Species Summaries for Soil Seed Bank Persistence. The Hawaii-Pacific Weed Risk Assessment evaluates the potential invasiveness of non-native plant species. Scores above 6 indicate high risk for invasiveness. *C. crocosmiiflora* has not been evaluated, but is a recognized invasive species in Hawai´i. Species with seeds that germinate without light and upon imbibition do so when they have absorbed enough water for germination. Other species have seeds that can remain in dark/imbibed treatment for years before germinating. If more than one collection per species, initial viability is an average.

Species	Family	HPWRA Risk	Habit	Year Test Began	Field Trial	Lab Trial	Initial Viability	Germinates Without Light?	Soil Seed Bank Type
Arthrostemma ciliatum	Melastomataceae	High (7)	herb	2007-ongoing		x	65%	no	Persistent, Long Term
Cenchrus setaceus	Poaceae	High (26)	grass	2012-2013	x	x	92%	yes (upon imbibition)	Transient
Chromolaena odorata	Asteraceae	High (28)	herb	2011-ongoing	x		73%	no	Persistent, Short Term
Crocosmia x crocosmiiflora	Iridaceae	-	herb	2008-2010	x		60%	yes (upon imbibition)	Transient
Ehrharta stipoides	Poaceae	High (19)	grass	2015-ongoing		x	100%	yes (upon imbibition)	Transient
Juncus effusus	Juncaceae	High (21)	rush	2007-2015	x	x	72%	no	Persistent, Long Term
Lantana camara	Verbenaceae	High (32)	shrub	2005-2012		x	48%	yes (after 5 years)	Persistent, Short Term
Rubus rosifolius	Rosaceae	High (10)	herb	2005-2011		x	46%	yes (after 2 years)	Persistent, Short Term
Schizachyrium condensatum	Poaceae	High (13)	grass	2013-ongoing	x		37%	no	Persistent (ongoing)

MANAGEMENT IMPLICATIONS

- Seed dormancy can complicate the assessment of soil seed bank persistence and needs to be identified and considered in determining soil persistence.
- Additional, extended trials are necessary for replication to verify seed bank classification and to continue testing species with suspected long-term persistent soil seed banks.
- Assuming no ingress of seeds or other propagules, isolated infestations of species with transient seed banks (*C. setaceus, C. crocosmiiflora,* and *E. stipoides*) have a good prognosis for eradication. Such infestations should be monitored at least 1.5 years following the removal of the last mature plant.
- Given that plant detection rates vary widely based on terrain, vegetation, staff, detectability of small size classes, etc., it is prudent to assume that some plants will escape detection for one or more control trips. Conservative managers may therefore choose to define eradication as no plants found for at least two times the duration of the soil seed bank.
- Species which form persistent, short term seed banks pose a greater challenge for eradication than those which form transient seed banks, and may require a decade of monitoring following eradication of the last known individual plant. Species which form persistent, long term seedbanks will require decades of consistent effort to achieve eradication.
- If habitat restoration, rather than eradication, is the goal, seed bank persistence is one factor to consider when determining time between weed control trips and setting realistic tolerance levels for select weeds in work sites.