plants

# Simulated photovoltaic solar panels alters the seed bank survival of desert annual plant species

**Supporting Information**

**Rebecca R. Hernandez[1,2*], Karen E. Tanner[3], Sophia Haji[3], Ingrid M. Parker[3], Bruce M. Pavlik[4], and Kara A. Moore-O'Leary[5]**

1 Department of Land, Air & Water Resources, University of California, Davis, One Shields Avenue, Davis, CA 95616
2 Wild Energy Initiative, John Muir Institute of the Environment, University of California, Davis, One Shields Avenue, Davis, CA 95616
3 Ecology and Evolutionary Biology Department, University of California, Santa Cruz, 1156 High St, Santa Cruz, CA 95064
4 Conservation Department, Red Butte Garden and Arboretum, University of Utah, Salt Lake City, UT 84108
5 U.S. Fish and Wildlife Service, Pacific Southwest Region, 3020 State University Drive East, Sacramento, CA 95819
* Correspondence: rrhernandez@ucdavis.edu

Received: date; Accepted: date; Published: date

Figure S1. The retained seed pool from seed bank packets collected in 2017 and 2018.

Figure S2. Seed staining rate (%) for the subsets of retained seed from packets collected in 2017 and 2018; percentages of stained *E. mohavense* seed are shown for the 2015 seed cohort and the 2016 seed cohort.

Figure S3. The seed bank survival model showing empirical seed bank pools and types in the Control and Shade microhabitats for (a) *E. mohavense* and (b) *E. wallacei* (averaged across cohorts for each species) after two years of burial.

Table S1. Sample sizes for packets recovered at the (a) Caliche Pan (*E. mohavense*), and (b) Gravelly Bajada (*E. wallacei*) site.

Table S2. Average retained seed pool for each species broken down by year of packet collection, seed cohort, and microhabitat.

Table S3. Average seed staining rates for each species broken down by year of packet collection, seed cohort, and microhabitat.

Table S4. Retained seed pools, seed staining rates, and calculated seed bank survival (%) from field data.

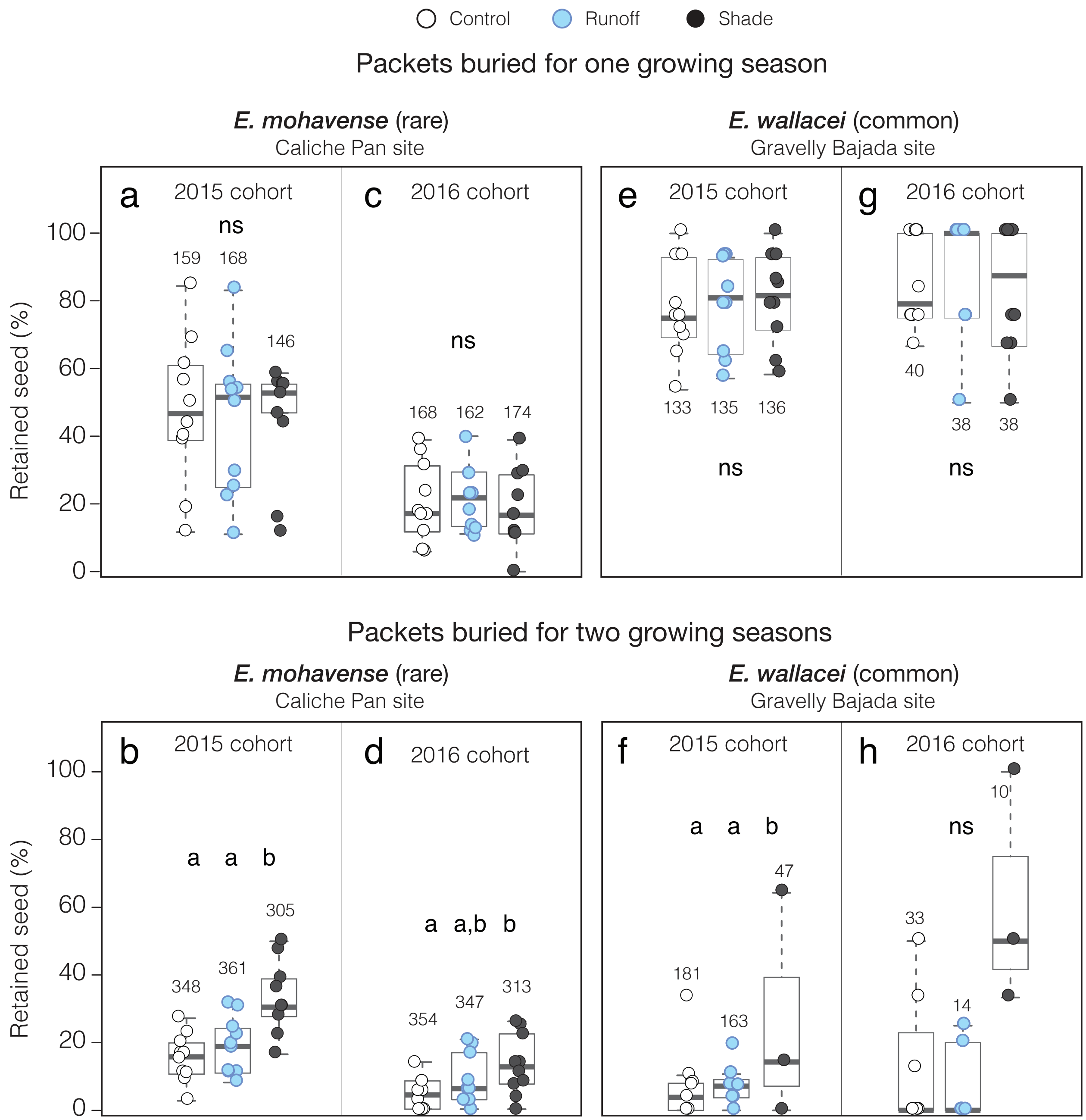


**Figure S1.** The retained seed pool from seed bank packets collected in 2017 (top row) and 2018 (bottom row). Percentages of retained, intact *E. mohavense* seed are shown in (a, b) for the 2015 seed cohort, and (c, d) for the 2016 seed cohort. Percentages of retained *E. wallacei* seed are shown in (e, f) for the 2015 seed cohort, and (g, h) for the 2016 seed cohort. Data points overlaid on boxplots show the number of packets collected from each microhabitat, and the numbers above each boxplot show the total number of seeds recovered from collected packets. Where letters above boxplots differ, the percentages of retained seed recovered were significantly different at the $p < 0.05$ level. Retained seed pools broken down by species, cohort, and microhabitat are provided in Table S2.

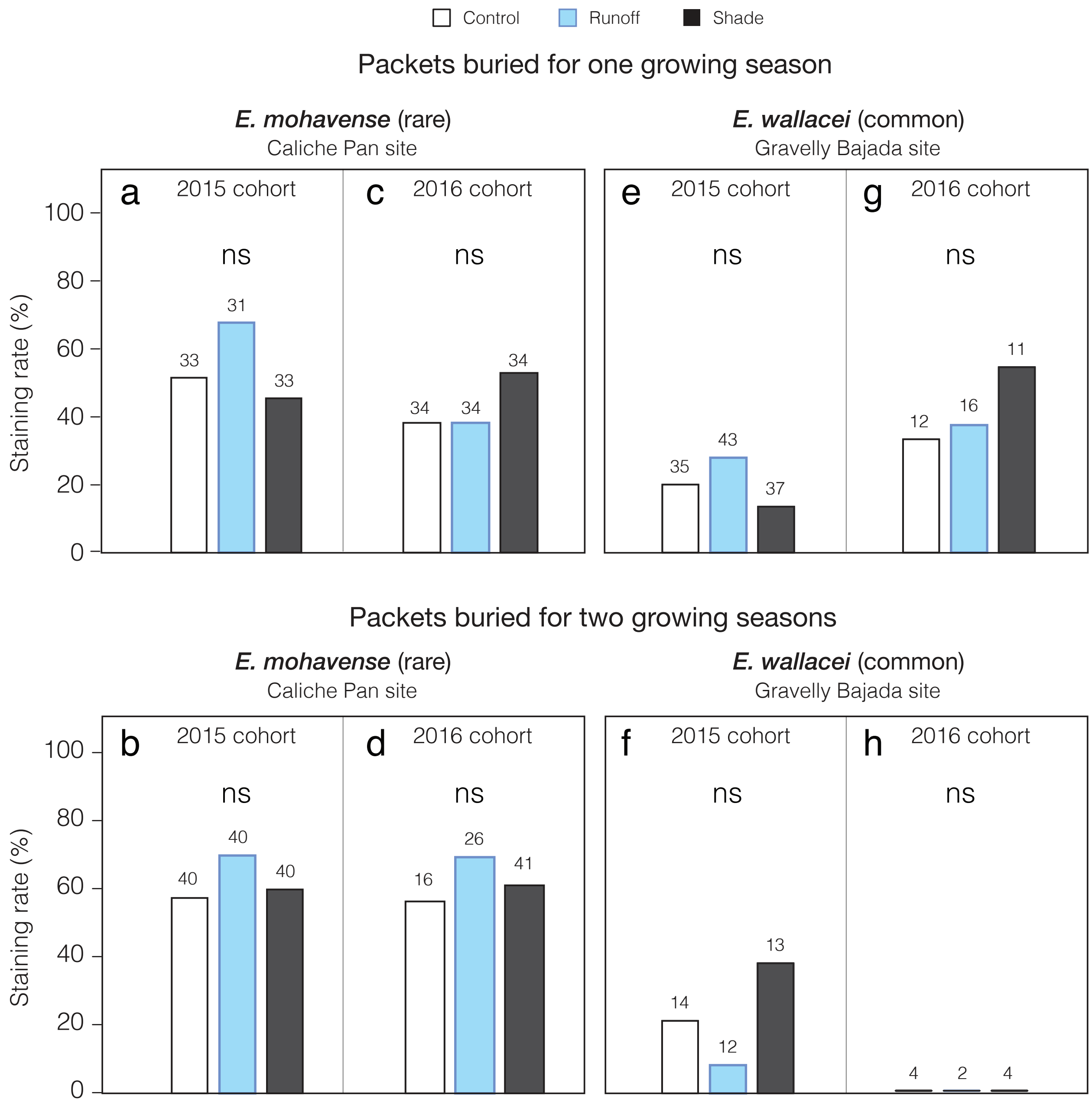


**Figure S2.** Staining rate (%) for the subsets of retained seed from packets collected in 2017 (top row) and 2018 (bottom row); percentages of stained *E. mohavense* seed are shown in (a, b) for the 2015 seed cohort, and (c, d) for the 2016 seed cohort. Percentages of stained *E. wallacei* seed are shown in (e, f) for the 2015 seed cohort and (g, h) for the 2016 seed cohort. Numbers above bar plots represent the total number of intact seeds subjected to tetrazolium assays. Final seed bank survival (%) is calculated by multiplying the retained seed pool by the proportion (i.e., decimal form of the percent) of the staining rate (see Supplementary Information, Table S3 for full seed bank survival calculations).

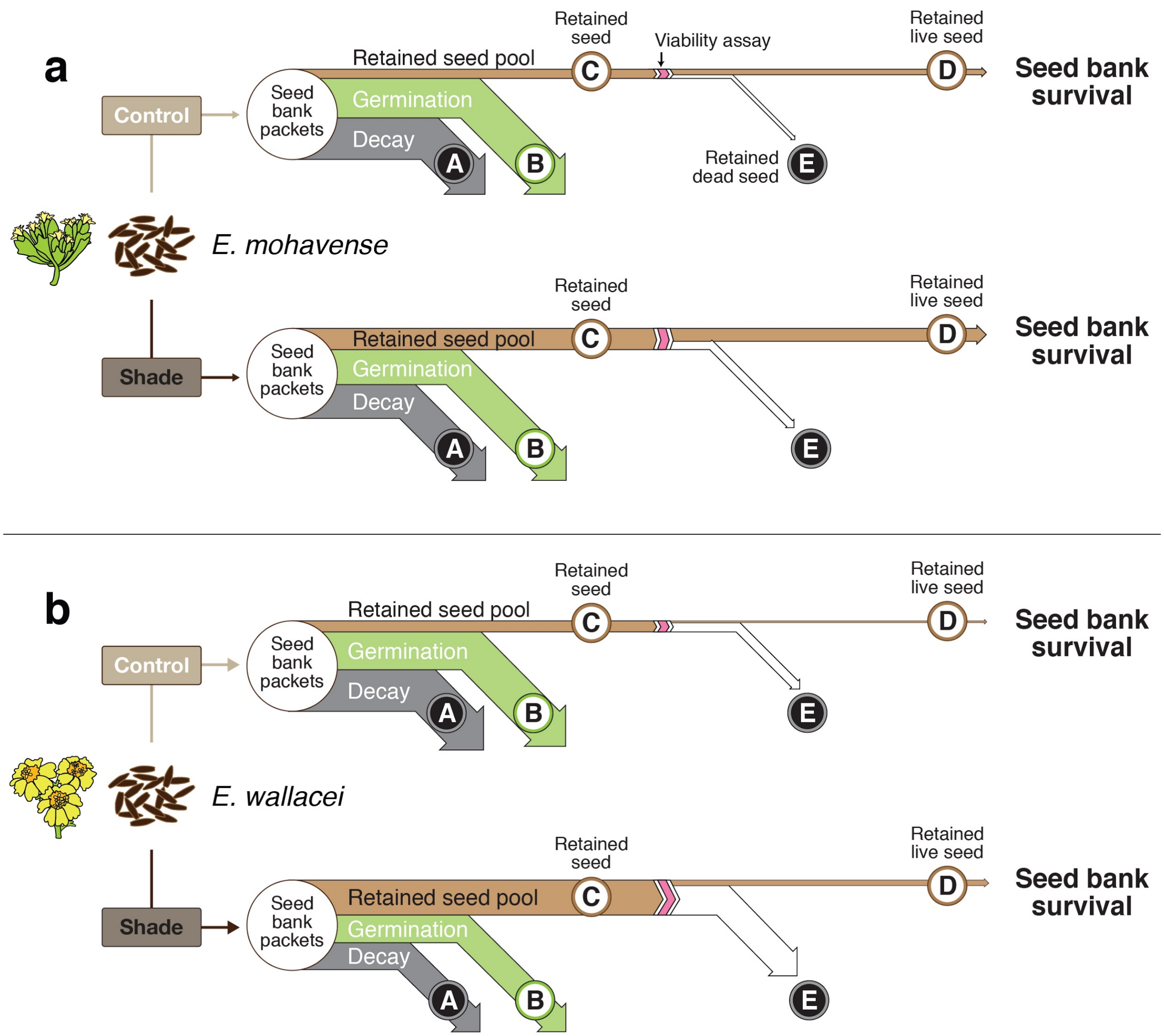


**Figure S3.** The seed bank survival model showing empirical seed bank pools and types in the Control and Shade microhabitats for (a) *E. mohavense* and (b) *E. wallacei* (averaged across cohorts for each species) after two years of burial. We observed higher seed retention in the Shade compared to the other two microhabitats (we show only Shade and Control flows here; flows in the Runoff microhabitat are very similar to Control flows). We cannot confidently partition decayed seed (flow A) from germinated seed (flow B) in the expended seed pool (due to the delay between the winter annual germination period and collection of packets in spring), so we visualize these flows as equivalent in size. Flows exiting the staining assay (pink chevron) visualize the percentage of live seed for a subset of the retained seed pools (C) exposed to staining assays.

plants

MDPI

**Table S1.** Sample sizes for packets recovered at the (a) Caliche Pan (*E. mohavense*) and (b) Gravelly Bajada (*E. wallacei*) site.

| | Year collected | Seed cohort | Microhabitat | Total seeds | Total packets |
|---|---|---|---|---|---|
| **(a)** ***E. mohavense*** | | | | | |
| | 2017 | 2015 | Control | 159 | 10 |
| | | | Runoff | 168 | 10 |
| | | | Shade | 146 | 9 |
| | | 2016 | Control | 168 | 19 |
| | | | Runoff | 162 | 20 |
| | | | Shade | 174 | 20 |
| | 2018 | 2015 | Control | 348 | 20 |
| | | | Runoff | 361 | 20 |
| | | | Shade | 305 | 17 |
| | | 2016 | Control | 354 | 40 |
| | | | Runoff | 347 | 40 |
| | | | Shade | 313 | 34 |
| **(b)** ***E. wallacei*** | | | | | |
| | 2017 | 2015 | Control | 133 | 10 |
| | | | Runoff | 135 | 10 |
| | | | Shade | 136 | 10 |
| | | 2016 | Control | 40 | 21 |
| | | | Runoff | 38 | 20 |
| | | | Shade | 38 | 20 |
| | 2018 | 2015 | Control | 181 | 14 |
| | | | Runoff | 163 | 12 |
| | | | Shade | 47 | 4 |
| | | 2016 | Control | 33 | 18 |
| | | | Runoff | 14 | 8 |
| | | | Shade | 10 | 5 |

**Table S2.** Average retained seed pool for each species broken down by year of packet collection, seed cohort, and microhabitat. Rows where packets were collected at less than 10 plots indicate a loss of packets in the field. Rabbits were observed digging around buried packets and were the likely culprits of their disappearance (Tanner, *pers. observ*.). Most packets were lost in the second year at the Gravelly Bajada (*E. wallacei*) site.

| Species | Year packets collected | Seed cohort | Microhabitat | Number of plots | Number of seeds recovered | Retained seed pool | Retained seed (%) |
|---|---|---|---|---|---|---|---|
| **a)** ***E. mohavense*** | | | Control | 10 | 159 | 74 | 0.47 |
| | | 2015 | Runoff | 10 | 168 | 75 | 0.45 |
| | | | Shade | 9 | 146 | 65 | 0.45 |
| | 2017 | | | | | | |
| | | | Control | 10 | 168 | 34 | 0.20 |
| | | 2016 | Runoff | 10 | 162 | 35 | 0.22 |
| | | | Shade | 10 | 174 | 32 | 0.18 |
| | | | Control | 10 | 348 | 53 | 0.15 |
| | | 2015 | Runoff | 10 | 361 | 68 | 0.19 |
| | | | Shade | 9 | 305 | 99 | 0.32 |
| | 2018 | | | | | | |
| | | | Control | 10 | 354 | 16 | 0.05 |
| | | 2016 | Runoff | 10 | 347 | 30 | 0.09 |
| | | | Shade | 10 | 313 | 44 | 0.14 |
| **b)** ***E. wallacei*** | | | Control | 10 | 133 | 103 | 0.77 |
| | | 2015 | Runoff | 10 | 135 | 107 | 0.79 |
| | | | Shade | 10 | 136 | 110 | 0.81 |
| | 2017 | | | | | | |
| | | | Control | 10 | 40 | 34 | 0.85 |
| | | 2016 | Runoff | 10 | 38 | 34 | 0.89 |
| | | | Shade | 10 | 38 | 32 | 0.84 |
| | | | Control | 9 | 181 | 17 | 0.09 |
| | | 2015 | Runoff | 7 | 163 | 13 | 0.08 |
| | | | Shade | 3 | 47 | 13 | 0.28 |
| | 2018 | | | | | | |
| | | | Control | 7 | 33 | 5 | 0.15 |
| | | 2016 | Runoff | 5 | 14 | 2 | 0.14 |
| | | | Shade | 3 | 10 | 5 | 0.50 |

**Table S3.** Average seed staining rates for each species broken down by year of packet collection, seed cohort, and microhabitat.

| | Species | Year packets collected | Seed Cohort | Microhabitat | Number of seeds assayed | Retained live seed pool | Staining rate |
|---|---|---|---|---|---|---|---|
| **a)** | ***E. mohavense*** | 2017 | 2015 | Control | 33 | 17 | 0.52 |
| | | | | Runoff | 31 | 21 | 0.68 |
| | | | | Shade | 33 | 15 | 0.45 |
| | | | 2016 | Control | 34 | 13 | 0.38 |
| | | | | Runoff | 34 | 13 | 0.38 |
| | | | | Shade | 34 | 18 | 0.53 |
| | | 2018 | 2015 | Control | 40 | 23 | 0.58 |
| | | | | Runoff | 40 | 28 | 0.70 |
| | | | | Shade | 40 | 24 | 0.60 |
| | | | 2016 | Control | 16 | 9 | 0.56 |
| | | | | Runoff | 26 | 18 | 0.69 |
| | | | | Shade | 41 | 25 | 0.61 |
| **b)** | ***E. wallacei*** | 2017 | 2015 | Control | 35 | 7 | 0.20 |
| | | | | Runoff | 43 | 12 | 0.28 |
| | | | | Shade | 37 | 5 | 0.14 |
| | | | 2016 | Control | 12 | 4 | 0.33 |
| | | | | Runoff | 16 | 6 | 0.38 |
| | | | | Shade | 11 | 6 | 0.55 |
| | | 2018 | 2015 | Control | 14 | 3 | 0.21 |
| | | | | Runoff | 12 | 1 | 0.08 |
| | | | | Shade | 13 | 5 | 0.38 |
| | | | 2016 | Control | 4 | 0 | 0 |
| | | | | Runoff | 2 | 0 | 0 |
| | | | | Shade | 4 | 0 | 0 |

**Table S4.** Retained seed pools, staining rates, and seed bank survival (%, calculated using Equation 1) from field data. (a) Empirical values by year and species (averaged across cohorts and microhabitats); (b) empirical values by year and microhabitat (averaged across species and cohorts). Retained seed pools and seed staining rates broken down by species, year, cohort, and microhabitat are provided in Tables S2 and S3.

| | Year collected | Retained seed pool | Staining rate | Seed bank survival |
|---|---|---|---|---|
| **a) By species, all microhabitats combined** | | | | |
| *E. mohavense* | 2017 | 32.7% | 49.0% | 16.7% |
| *E. wallacei* | 2017 | 82.7% | 31.1% | 26.1% |
| *E. mohavense* | 2018 | 15.6% | 62.3% | 9.8% |
| *E. wallacei* | 2018 | 20.7% | 11.4% | 2.2% |
| **b) By microhabitat, both species combined** | | | | |
| Control | 2017 | 57.3% | 35.8% | 18.9% |
| Runoff | 2017 | 58.7% | 42.8% | 23.5% |
| Shade | 2017 | 57.0% | 41.6% | 21.7% |
| Control | 2018 | 11.1% | 33.8% | 3.3% |
| Runoff | 2018 | 12.4% | 36.9% | 5.0% |
| Shade | 2018 | 31.0% | 39.9% | 9.7% |