Long-term population dynamics of individually mapped Sonoran Desert winter annuals from the Desert Laboratory, Tucson AZ

D. L. Venable

INTRODUCTION

Desert annual plants have played an important role as model organisms in the development of understanding of how organisms adapt to variable and unpredictable environments. They have also been used to exemplify ideas about non-equilibrium community dynamics in variable environments. Yet their dynamics are not well known empirically, especially the behavior of seeds. This data set on the population and community dynamics of desert annuals, provides the best available long-term data to test these ideas. There has been considerable theoretical and experimental work carried out on the evolutionary ecology, population ecology and community ecology of this system. Such combinations of theoretical and experimental work with long-term observations are proving to be a powerful approach to yield new insights and syntheses in plant ecology.

The main goal of this research was to determine how these plants adapt to and coexist in variable and unpredictable environments. The resulting long term population and community dynamic data has formed the backbone of a synthetic research program on desert annuals combining evolutionary, physiological, population and community ecological approaches to answer questions uniting functional biology, life history evolution and community dynamics.

This data set consists of a continuous record of population and community dynamics of desert winter annual plants on permanent plots at a Sonoran Desert site at the Desert Laboratory near Tucson, AZ, USA. It was collected to clarify and extend the understanding of demographic variation and covariation and its role in population and community processes. Data on germination, survival and reproduction of desert annual plants has been continuously monitored on long-term plots established in 1982 at locations both under shrub canopies and in the open at this field station. Delayed germination and between year seed carry over are thought to be important for the persistence of desert annuals, so the magnitude of the soil seed reserves has been monitored to determine what fraction of the seeds germinate in each year for each species under shrubs and in the open. Seeds have been separated from standardized soil samples and tested for viability.

METADATA CLASS I. DATA SET DESCRIPTORS

A. Data set identity:

Title: Long-term population dynamics of individually mapped Sonoran Desert winter annuals from the Desert Laboratory, Tucson AZ

B. Data set identification code

C. Data set description

Principal Investigator: D. Lawrence Venable, Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 85721 USA

Abstract:

Desert annual plants have played an important role as model organisms in the development of understanding of how organisms adapt to variable and unpredictable environments. They have also been used to exemplify ideas about non-equilibrium community dynamics. The goal of this data set

is to provide a comprehensive long-term data set on demographic variation and covariation for a guild of desert winter annual plants. Germination, survival fecundity and seed bank dynamics have been assessed on a set of permanent plots since 1982 at the Desert Laboratory in Tucson, Arizona. Data is provided for individual plant including germination date, death date, fecundity, viable seed bank and in some years, Cartesian coordinates within plots. Viable seed densities for replicated soil samples are provided for all species since 1990. A species by year summary of vital rates is also provided.

D. *Key words: long-term population dynamics; demography; Sonoran Desert; annual plants, seed bank*.

CLASS II. RESEARCH ORIGIN DESCRIPTORS

A. Overall project description

Identity: Long-term population dynamics of individually mapped Sonoran Desert winter annuals from the Desert Laboratory, Tucson AZ

Originator: Dr. D. Lawrence Venable

Period of Study: 1982–2013

Objectives: To monitor the germination, survival, fecundity and seed bank dynamics of desert winter annuals

Abstract: same as above.

Source(s) of funding: National Science Foundation grants DEB 9419905 (LTREB), DEB 0212782 (LTREB), DEB 0717466 (LTREB), and DEB 0310400 (LTREB).

B. Specific subproject description

1. Site description: Permanent quadrats were established in 1982 at the northwest base of Tumamoc Hill at the Desert Laboratory of the University of Arizona in Tucson, Arizona.

Site type: The site (725 m elevation) is a gently sloped creosote flat dominated by *Larrea divaricata* (creosote bush), which has 50% cover. The site is located in the Arizona Upland subdivision of the Sonoran Desert.

Geography: The study site is located at the northwest base of Tumamoc Hill 1 mile west of downtown Tucson, AZ (32'13" N, 111'01" W).

Habitat: See "Site type" above. The quadrats extend along a transect from a flat alluvial area and up the southeast side of a gently sloping (9°) hill,.

Geology: Plots are located along a gently sloping bajada (fluvial piedmont) of consistent parent material, where a strong transition occurs in the age of the soil surface with elevation. The soil on the slope is composed of basaltic andesite (Phillips 1976) with a coarse sandy-loam texture (67% sand, 20% silt, 13% clay) and with fragments ofbasaltic rocks embedded in the surface. The surrounding lower areas have recently derived alluvial soil, including sandy-clay soil at the base of the hill (54% sand, 22% silt, 24% clay) and loamy-sand soil in a series of shallow (<0.5 m deep) and narrow (2-3 m wide) dry drainage channels (79% sand, 10°/o silt, 10% clay). The slope is rockier (50% gravel) than the base of the hill (20% gravel) or rivulets (25% gravel) (Pantastico-Caldas and Venable 1993).

Watersheds/hydrology: N/A

Site history: The 850 acre Desert laboratory site was fences in 1906 to protect it from cattle grazing and it has been an ecological preserve subsequently.

Climate: The site receives ~300 mm of annual precipitation on average, about half of which falls during the summer monsoons (July–September), with the rest occurring sporadically through the remainder of the year (Bowers and Turner 1985).

2. Experimental design: There are seventy two permanent plots randomly placed along two parallel transects. At each of thirty six random positions along the transects there is one plot under a creosote bush shrub canopy and a matching open plot at least 1m from the nearest shrub.

Design characteristics: N/A

Permanent Plots: 0.1 m2 permanent plots.

Data Collection Period, Frequency: In 1982 I began censusing 15 permanent plots along a 250 m transect at the study site. In 1989, 48 additional long-term study plots were established and in 1991 the total number was increased to 72, one half being located under shrubs and one half in the open. The plots have been visited following each rainfall during the germination season to check for germination. When there is more than trace germination (> 1% of expected total year germination) a germination census is conducted. Following a germination census, subsequent censuses are conducted at intervals sufficiently short to recognize individual plants and distinguish survival from mortality followed by new germination (i.e., every 30-45 days). Frequently, more than one cohort per year emerges from precipitation associated with different storm systems. Each cohort is scored separately. Fecundity has been scored on a random subsample of five surviving plants from each species in each cohort in each plot at the end of the growing season. In early years 1982- 199? it was recorded for every surviving plant. Systematic annual collection of soil cores for seed bank analysis began in 1990. The cores are collected after the germination season, but prior to seed set from the following season, i.e., in February of each year.

3. Research Methods

Field/Laboratory: Each seedling is mapped with exact location and species identity with colored markers on acetate sheets placed with fixed coordinates over plexiglass mapping tables. The mapping tables are set over the plots in the field. At the end of the season, maps are scored to record germination and death dates, and fecundity for individual plants. This sampling and data recording scheme has been used consistently for the whole period of data collection. From this data we have calculated mean survival from germination to reproduction and mean fecundity of survivors for each cohort of each species in shrub and open habitats each year. From this we calculated the average seed set per seedling (per capita reproductive success) for each cohort of each species in the open and shrub habitats each year (proportion surviving times mean fecundity of survivors).

We collect 180 soil cores (5.4 cm diameter x 2.5 cm deep) annually using stratified random sampling (Benoit et al. 1989) along a transect connecting the 2 demographic transects for the 24- and 17-year old plots. Half of the samples are obtained from under creosote shrubs and half from open sites. The cores are collected after the germination season, but prior to seed set from the following season. Thus the viable seeds in these samples have forgone germination in at least one season. Viable seeds rarely occur below 2.5 cm in the study area. Samples are placed in paper bags to insure evaporation of any soil moisture, and if the soil is moist at the time of collection, the paper bags are opened and placed beneath fans to insure rapid drying with no further rot or germination.

Seeds and organic material are separated from soil particles using a repetitive frothing, flotation, and filtering technique which has been shown to retrieve >95% of seeds in blind tests. Individual soil samples are mixed with tap water and stirred vigorously. The suspension containing floating organic matter and small soil particles are then immediately decanted through an organza-cloth filter placed in a Buchner funnel attached to suction. This filter has been shown to capture all seeds of the smallest-seeded species in this guild of annual plants (*Evax multicaulis*, mean seed size, 0.025 mg). This process is repeated multiple times until the decanted liquid is clear. Then the organza filter and debris are placed in a labeled petri dish and oven dried for >24 hrs at 40C. The organic matter with seeds is then sifted with standard testing sieves and all fractions that potentially contain seeds from the annual plant guild are spread out a spoonful at a time and examined under a dissecting microscope. All seeds are separated, counted, and identified to species by comparison to voucher seeds. The seeds are cut or poked through the seed coat to determine viability. Seeds with juicy, oily, or fleshy embryos or endosperm are scored as viable. Tetrazolium chloride testing gives inferior results due to the difficulty of manipulating our smallest seeds and because some deeply dormant viable seeds show only minimal staining. Under the field conditions from which these soil samples are collected seeds usually undergo easily recognizable changes upon death (dessication or decay of endosperm or embryo). Counting of viable seeds is superior for our system to the germination-based procedures sometimes used in other seed bank studies because viable seeds of our species often do not germinate completely (Adondakis and Venable 2004).

Instrumentation: N/A

Taxonomy and systematics: Plant names are per Bowers and Turner (1985).

Permit history: N/A

Legal/organizational requirements: None.

4. Project personnel: Sandy Adondakis, Amy Angert, Greg Barron-Gafford, Ursula Basinger, Amy Bell, Tony Caprio, Maria Clauss, Ben Collins, Jonathan Cox, Michelle Davis, Norm Douglas, Jonathan Duke, Carrie Enquist, Gordon Fox, Kathy Gerst, Kevan Gilliam, Christine Golightly, Jenny Gremer, Alice Halloran, Amelia Hazard, Jonathan Horst, Tani Hubbard, Travis Huxman, Renee Janaway, Amanda Jaksha, Bruce Kendall, Greg Ketner, Oxana Kougot, Holly Lawson, Kristen McCoy, Chris McDonald, Ken Moriuchi, Cathie Pake, Marissa Pantastico, Catherine Pearson, Jim Pearson, Stephanie Roberts, Pilar Sanchez, Marcelo Schneider, Sabrina Stebens, Michelle Stubbs, Michael Wagenheim and Brian Weeks.

CLASS III. DATA SET STATUS AND ACCESSIBILITY

A.Status

Latest Update: Feb. 2013

Latest Archive date: June 2012

Metadata status: The metadata are complete and up to date.

Data verification: See V. A. 3.

B.Accessibility

Storage location and medium: Data is available at http://www.eebweb.arizona.edu/faculty/venable/LTREB.htm. It is also on the several personal

computers and DVDs at the Venable lab in Excel files and an Access database.

Contact person: D. Lawrence Venable, Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ 95721 USA, E-mail: venable@email.arizona.edu.

Copyright restrictions: None.

Proprietary restrictions: None.

Costs: None.

CLASS IV. DATA STRUCTURAL DESCRIPTORS

SPECIES BY YEAR MEANS

A. Data Set File

Identity: species_x_year.csv

Size: 18,014 bytes.

Format and storage mode: ASCII text, comma separated. No compression scheme was used.

Header information: The first row of the file contains the variable names below.

Alphanumeric attributes: Mixed.

Special characters/fields: N/A

Authentication procedures: MD5 Checksum for the file: 6f80aa9b810796934b12dd759fd18069

B. Variable information

Variable name	Variable definition	Units	Storage type	Range numeric value codes	Variable codes and definitions
species	Species	N/A	Character	N/A	Species acronym consists of the first two letters of the genus and species, e.g. *Evax multicaulis* is coded as "evmu"
year	Year	N/A	Integer	N/A	Year is coded as the Spring year, e.g., Fall 1982-Spring 1983 is coded "1983".
germ	Number of seedlings that emerged	seedlings	Integer	0-4638	N/A
survive	Number of the plants surviving to the reproductive census	plants	Integer	0-2380	This number was obtained by following the individual seedlings counted in "germ".

seedlings per m2	seedlings per meter squared	seedlings/m2	Floating Point	0-2497.14	This is converted from "germ"
lx	Survival	plants/seedling	Floating Point	0.00-1.00	proportion of seedlings surviving to reproduction (=survive/germ). "." means undefined, which occurs when germ = 0.
bx	per capita seed production	seeds/plant	Floating Point	0.00-1098.53	Average number of seeds per plant surviving to the reproductive census. "." means undefined (no seedlings surviving to reproduce) or rarely, missing data.
lxbx	reproductive success	seeds/seedling	Floating Point	0.00-917.80	Probability of surviving from emergence to reproduction x mean seed set of reproductive plants (lx times bx). ("." means undefined, i.e., germ = 0).
seeds per m2	Number of viable seeds per m2 in the soil seed bank	seeds	Floating Point	0-24,137.56	N/A
germ fraction	proportion of seeds in the seed bank that germinated	seedlings/seed	Floating Point	0.00-1.00	seedlings per m2/(seedlings per m2+seeds/m2). "." means undefined, i.e., no seeds or seedlings in samples monitored.

INDIVIDUAL PLANT CENSUS DATA

A. Data Set File

Identity: census_data.csv

Size: 5,512,180 bytes.

Format and storage mode:ASCII text, comma separated. No compression scheme was used.

Header information: The first row of the file contains the variable names below.

Alphanumeric attributes: Mixed.

Special characters/fields: N/A

Authentication procedures: MD5 Checksum for the file: 6f80aa9b810796934b12dd759fd18069

B. Variable information

Variable name	Variable definition	Units	Storage type	Range numeric value codes	Variable codes and definitions

year	Year	N/A	Integer	N/A	Year is coded as the Spring year, e.g., Fall 1982-Spring 1983 is coded "1983".
plot-habitat-replicate	Quadrat identifier	N/A	Character	N/A	plot number, habitat type ("shrub" or "open"), and replicate
species	Species	N/A	Character	N/A	Species acronym consists of the first two letters of the genus and species, e.g. *Evax multicaulis* is coded as "evmu"
germ date	Germination census date	mm/dd/yyyy	Date	N/A	Census at which seedling was first recorded.
death date	Death census date	mm/dd/yyyy	Date	N/A	First census at which plant was no longer alive or date of reproductive census if plant survived to the final census.
seeds	lifetime seed production	seeds	floating point	0.00-8000	"-99" means this plant reproduced but was not in the sub sample for which reproduction was counted.
plot group	plot group identifier	N/A	Character	N/A	"ltp" are plots that were first censused in 1982-1983. "gfp" are plots that were first censused in 1989-1990.
x	horizontal plant position coordinate	mm	integer	0-545	horizontal distance of the plant from the "lower left" corner of the quadrat
y	vertical plant position coordinate	mm	integer	0-248	vertical distance of the plant from the "lower left" corner of the quadrat

SEED BANK DATA

A. Data Set File

Identity: seed_bank.csv

Size: 4,216,923 bytes.

Format and storage mode: ASCII text, comma separated. No compression scheme was used.

Header information: The first row of the file contains the variable names below.

Alphanumeric attributes: Mixed.

Special characters/fields: N/A

Authentication procedures: MD5 Checksum for the file: 6f80aa9b810796934b12dd759fd18069

B. Variable information

Variable name	Variable definition	Units	Storage type	Range numeric value codes	Variable codes and definitions
year	Year	N/A	Integer	N/A	Year is coded as the Spring year, e.g., Fall 1982-Spring 1983 is coded "1983".
plot	Letter corresponding to sequential 10 m segments along a transect	N/A	Character	D-Y	N/A
habitat	Under shrub canopy or in open habitat between shrubs	N/A	Character	N/A	N/A
replicate	identifier for a random seed sample nested within plot and habitat	N/A	Integer	1-10	Number identifying the replicate.
species	Species	N/A	Character	N/A	Species acronym consists of the first two letters of the genus and species, e.g. *Evax multicaulis* is coded as "evmu"
seeds	Number of viable seeds in sample	seeds	Integer	0.00-1073.33	N/A
area	area of seed sample	cm2	Floating Point		N/A
seeds per m2	Number of viable seeds per m2 in the soil seed bank	seeds/m2	Floating Point	0-24,137.56	N/A

SPECIES LIST

A. Data Set File

Identity: species_list.csv

Size: 3,617 bytes.

Format and storage mode: ASCII text, comma separated. No compression scheme was used.

Header information: The first row of the file contains the variable names below.

Alphanumeric attributes: Mixed.

Special characters/fields: N/A

Authentication procedures: MD5 Checksum for the file: 6f80aa9b810796934b12dd759fd18069

B. Variable information

Variable name	Variable definition	Units	Storage type	Range numeric value codes	Variable codes and definitions
genus	Latin genus name	N/A	Integer	N/A	Year is coded as the Spring year, e.g., Fall 1982-Spring 1983 is coded "1983".
species	Latin species name	N/A	Character	N/A	*Genus species* name as current when the lab started
acronym	Species acronym	N/A	Character	N/A	Species acronym consists of the first two letters of the genus and species, e.g. *Evax multicaulis* is coded as "evmu"
family	identifier for a random seed sample nested within plot and habitat	N/A	Integer	N/A	FAMILY (e.g. BORAGINACEAE)
synonym	The synonym for the species name in the USDA PLANTS database when the species name used here does not correspond to the primary name given in the PLANTS database at http://plants.usda.gov	N/A	Character	N/A	N/A

CLASS V. SUPPLEMENTAL DESCRIPTORS

A. Data acquisition

Data forms: NA

Location of completed data forms: The original maps and data sheets are stored in the Venable lab at the Department of Ecology and Evolutionary Biology.

Data entry verification procedures: See II.B.3., Research Methods.

B. Quality assurance/quality control procedures: All plant data with Cartesian map coordinates were entered from the acetate maps with a Summagraphics digitizing table to .txt files. Plant data without coordinates were collected onto standardized data forms from the maps prior to transferring to Excel files. All computer data entry was double checked visually after original data entry. Files were scanned for outliers. Outliers were checked against data forms or original maps.

Soil seeds were identified and checked for species ID as described in II.B.3. Seed ID's were spot checked by a supervisor before and after viability determination. Acuracy of the people sorting seeds also was verified by blind testing involving counted seeds placed in samples previously without seeds.

C. Related material:

D. Computer programs and data processing algorithms:

E. Archiving:

Archival Procedures:

Redundant Archival Sites:

F. Publications and results:

Venable, D.L. 1989. Modeling the evolutionary ecology of seed banks. pp. 67-87 In: Leck, M.A., V.T. Parker, and R.L. Simpson, editors, The ecology of soil seed banks. Academic Press, San Diego.

Pantastico, M. and D.L. Venable. 1993. Competition in two species of desert annuals along a topographic gradient. Ecology 74: 2192-2203.

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Pake, C. and D.L. Venable. 1995. Is coexistence in Sonoran Desert annuals mediated by temporal variablility in reproductive success? Ecology 76:246-261.

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Moriuchi, K.S. D.L. Venable, C.E. Pake and T. Lange. 2000. Direct measurement of seed bank age structure of a Sonoran Desert annual plant. Ecology, 81:1133-1138

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Venable, D. L., A. Flores-Martinez, H. C. Muller-Landau, G. A. Barron-Gafford, and J. X. Becerra. 2008. Seed dispersal of desert annuals. Ecology. In Press.

Barron-Gafford, G. A., A. L. Angert, D. L. Venable, A. P. Tyler, K. L. Gerst, and T. E. Huxman. in review. Photosynthetic temperature responses of desert annuals with contrasting resource-use efficiencies. Oecologia. In Review.

H. History of data set usage

Data request history: N/A

Data set update history: N/A

Review history: N/A

Questions and comments from secondary users: N/A

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