Biodiversity in Urban Gardens Project Report Summer 2017
Environmental Studies Department, University of California, Santa Cruz

Dear Gardeners, Garden Managers, and Staff,

Here is our report for the Biodiversity in Urban Gardens Project conducted from May - October 2017 in your beautiful Central Coast gardens! This past summer saw lots of work studying plants, beneficial insect biodiversity, pollination, water conservation, as well as surveys with gardeners in 25 different gardens in our region. Most of the work completed this year was related to a USDA grant awarded in 2016. The goal of that project is to better understand how garden, landscape, and social diversity influences beneficial insects, pollination, pest control and water conservation, and ultimately food access and well-being for gardeners (Fig. 1). We also continued some work behind the scenes (in the lab!) to follow up on research questions launched in 2015. This summer, we trained 3 graduate students, 5 undergraduates, and 2 high school students. We conducted surveys with 187 gardeners about their management and well-being benefits. We again hosted scientists from Australia, Texas, Oregon and Michigan. Take home messages from our studies thus far are:

- **Pollination** -- Adding more flowers attracts pollinators (bees) and benefits crop pollination in urban gardens
- **Pest control** -- Adding insectary plants increases numbers of beneficial parasitoid wasps. Beneficial insects (ladybugs, wasps, spiders) thrive in gardens with more crop, weed, and ornamental plant species, with less leaf litter, and in gardens surrounded by less farmland.
- **Water use and conservation** -- Some gardeners use a lot of water, but participating in research improves their knowledge of how much water they use. Rules are important determinants of water use in gardens. Water loss is lower in gardens with more straw cover.
- **Food access and well-being** -- Many gardeners in our region suffer from food insecurity. But gardens provide a lot of food: 68% of gardeners harvest between 5-10 lbs. of fruits and veggies per week; an additional 14% say they harvest >20 lbs. per week. Further, 100% of gardeners surveyed report that gardening has improved the well-being of themselves or their families

Thanks for allowing us garden access, your time, letters of support for our grant proposals, and discussing your gardening practices with us. Please follow our research on our web page filled with reports, publications, and fun facts: https://www.urbangardenecology.com/. Please contact us with any questions or concerns, and we hope to continue working together in the future.

Sincerely,

Stacy Philpott (sphilpot@ucsc.edu)
Peter Bichier (pbichier@ucsc.edu)

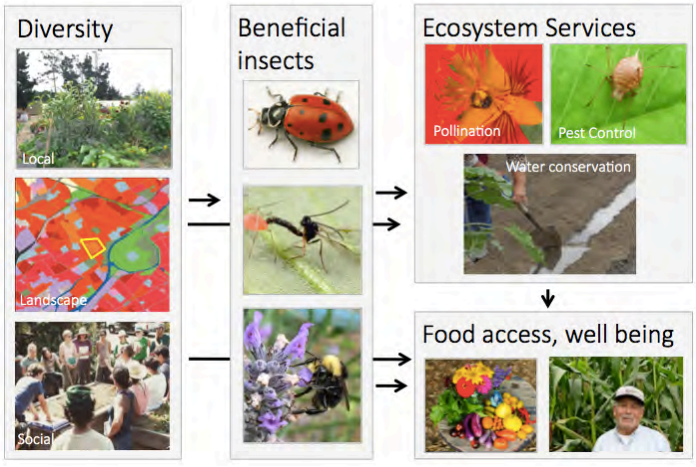


Fig. 1. The research framework for our USDA grant aiming to determine natural resources and production practices essential for the sustained long-term production of crops and ecosystem services within urban gardens.

What factors improve jalapeño pollination?

We want to learn how garden management influences the number of bees and bee species present in each garden, and how this, in turn, affects pollination services that bees deliver. Last July, we conducted pollination experiments at each garden site by placing jalapeño plants (raised in the greenhouse) in the different gardens for 2 days. We covered some flowers (preventing pollinator access) and left some flowers open to pollinator visits to compare how efficient and effective pollinators were in the different gardens. We found that open flowers produced more fruit than bagged flowers - or in other words, jalapeños benefit from pollinator visits. We also found that the number of flowers present in gardens increased pollination levels for jalapeños. ***This means that the total number of flowers in the garden can attract pollinators that benefit pollination of a single crop species!***

What kind of pollen do bumble bees carry?

One of our goals is to give undergraduate students opportunities to conduct research and complete research theses. Zachariah Jordan and Diana-Joyce Ojeda are studying the number of pollen grains and the different species of pollen found on bumble bees (*Bombus vosnesenskii*). They are also trying to understand how the garden management (ground cover, plants) and landscape surroundings influence the pollen carried by bumble bees. Common pollen grains found on bumble bees that were easily identifiable were: tomato, tomatillo, borage and plants of the mint family (*Salvia* and basil mostly). Zachariah's analyses indicate that bees from gardens in very urban areas carry more pollen grains. Diana-Joyce has created a pollen library of the 75 most common flowering plant species – these will be used to match the grains on the bees to the plants that they come from. Want to see what we have seen on bumble bees and what pollen look like under a microscope? Take a look at the photos (Fig. 2)!

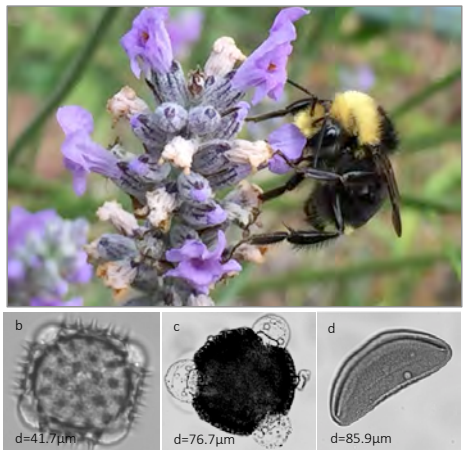


Fig. 2. Top – Bumble bee on a lavender plant. Bottom – sample of pollen grains photographed under the microscope.

How many tomatoes do gardeners produce?

We are interested in measuring pollination success and fruit production. In order to do this, we counted flowers and fruits of tomatoes, squash, and peppers at three time points during the summer (mid June, early July, late July). At each time, we counted the total number of unopened flowers, opened flowers, and fruits on 10 plants of each crop species, and also measured the size of the fruits. We found that a greater portion of flowers turn into fruits in the second half of the summer. Our data also show that squash fruit production is relatively constant throughout the summer, while pepper and tomato production increases in later summer (Fig. 3). Overall, we counted >7,000 tomatoes, peppers, and squash fruits in just 25 gardens!

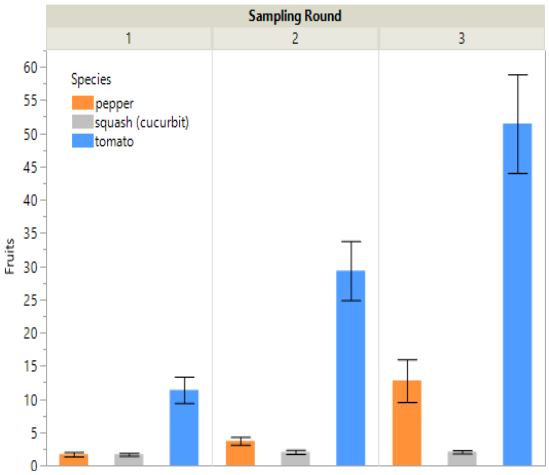


Fig. 3. Fruit production for peppers, squash, and tomatoes per plant during mid June (sample round 1), early July (2), and late July (3).

Releasing ladybugs - how long will they stay and why?

"Insectary" flowers are encouraged in gardens because they provide nectar, pollen and shelter for beneficial insects. In addition, many gardeners release ladybugs (purchased at garden stores) into their plots in order to control aphid pests, but we don't know how long ladybugs stick around or why. This summer we did an experiment to ask whether adding insectary plants into gardens (sweet alyssum, cilantro, chamomile) or landscape type (neighborhoods with lots of natural habitat vs. lots of urban habitat) influences ladybugs or parasitoid wasps -- two types of beneficial insects in the garden. We carefully released into gardens insectary plants and ladybugs marked with glow-in-the-dark powder (not harmful to ladybugs or humans) (Fig. 4). We found that adding flowers boosted numbers of parasitoid wasps, but did not affect ladybug populations or the time that ladybugs stayed in gardens. The landscape type did have a big impact on ladybugs, however. Ladybugs stayed much longer in gardens in neighborhoods with more natural habitat. ***Adding insectary plants increases numbers of beneficial parasitoid wasps. To promote ladybugs, neighborhood planning is necessary!***

Fig. 4. We studied how availability of flowers and garden landscape surroundings affect how long ladybugs stay in a garden. We placed plants with white flowers (alyssum, cilantro, chamomile) and ladybugs marked with glow-in-the-dark powder into gardens, and tracked for 10 days how many ladybugs stuck around. Ladybugs stay around longer in gardens with more natural habitat in the neighborhood.

What factors boost beneficial insects and bust pests on brassicas?

One crop found in each and every garden is *Brassica oleracea* - the single species that includes kale, cabbage, Brussels's sprouts, kohlrabi, broccoli, cauliflower, collard greens, and more. This summer, we stared at over 1,000 of these plants to search for pests (aphids, cabbage looper caterpillars, harlequin bugs) and their predators (ladybugs, spiders, ants, parasitoid wasps). We counted nearly 70,000 insects and spiders on the plants! We also measured general characteristics of the gardens to figure out how to boost the beneficials and bust the pests. Pests were especially abundant in gardens with lots of urban area in the surroundings, in gardens with more plant species, and in older gardens. ***We found more beneficials (parasitoids and predators) in gardens with more crop, weed, and ornamental plant species, with less leaf litter, and in gardens with less agriculture in the surrounding landscapes.***

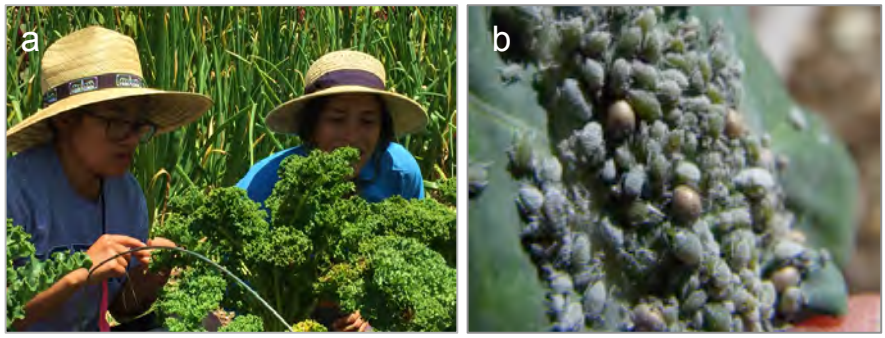


Fig. 5. Searching for bugs on brasscias. a) Carly Sanchez (L) and Heidi Liere (R) search for beneficial insects and pests on kale. b) cabbage aphids and parasitized aphids or aphid mummies (grey balls). Those aphid mummies have beneficial parasitoids growing inside!

How much water do gardeners use, and why?

There is a growing need to study urban agriculture water management. This is particularly true in California where recent drought has restricted water use and challenged urban gardens to conserve water. We continued a water-metering project again this summer, collaborating with 20 gardeners in 4 gardens to study their water, soil, and crop management. For the project we worked with gardeners to ask: How much water are gardeners using? How do garden variables affect temperature, water conservation, and use? Gardeners measured their own water use, and answered surveys about water use. We measured soil water moisture, vegetation and ground cover, and soil properties.

Soils: Gardens have relatively high soil organic matter content, and most gardeners (80%) use compost. Garden soils are comprised of sandy loam (70%), loamy sand (15%), loam (10%), or sandy clay loam (5%). Garden soil properties, vegetation, and ground cover vary greatly by garden (Table 1).

Water use: Gardeners used between **0.02 - 2.5 gallons per square foot** (or 1.3 - 104.5 liters /m^2) each time they went to the garden to water. Gardeners said that garden rules, regulations, and limits were the most important determinant of their water use (65% of gardeners), followed by the weather report (40%), plant needs (35%), other gardeners (15%), and the news/media (10%). Gardeners use more water when it is hot, and when they have more crops planted. Soil moisture is highly variable over time in response to water inputs (Fig. 5).

Water conservation: The rate of ***water loss is lower in gardens with more straw cover***. Gardeners conveyed that participating in the project was a learning experience. Before the study, 70% of gardeners report they did not know how much water they use. ***After the study, 45% of participants correctly estimated the amount of water that they use each time.***

Table 1. Summary statistics for water use, soil properties, and vegetation properties for volunteer gardener plots.

	Average	Min	Max
Water use variables			
Water used (liters per m^2)	31.4	1.3	104.5
Plot temp. at watering event C	25.3	15.3	33.5
Soil moisture (%)	0.2	0	0.3
Relative humidity (%)	76.1	68.6	83.6
Soil variables			
% Organic matter	19.2	9.4	28.8
% Water holding capacity	30.1	16.8	50.7
Inorganic Nitrogen (NO3-N ppm)	53.9	12	162
% Sand	63.6	46	86
% Silt	22.4	8	36
% Clay	14	6	20
Vegetation variables			
No. of crop species	5.2	2	14
% Crop cover	27.8	7	85
% Bare soil cover	47.5	5	85
% Grass cover	5	0	50
% Mulch	6.8	0	27.5
% Straw	19.6	0	87.5
Height of vegetation (avg. cm)	108.4	43	235
Canopy cover	3.3	0	17.5

Fig. 6. Water-metering study. a) temperature logger, b) Brenda Lin hooking up the soil moisture sensor equipment, c) water meter used in the experiment, d) gardeners filling out the data sheets.

Who are the gardeners? How much food do they produce? Are gardens important to gardener well-being?

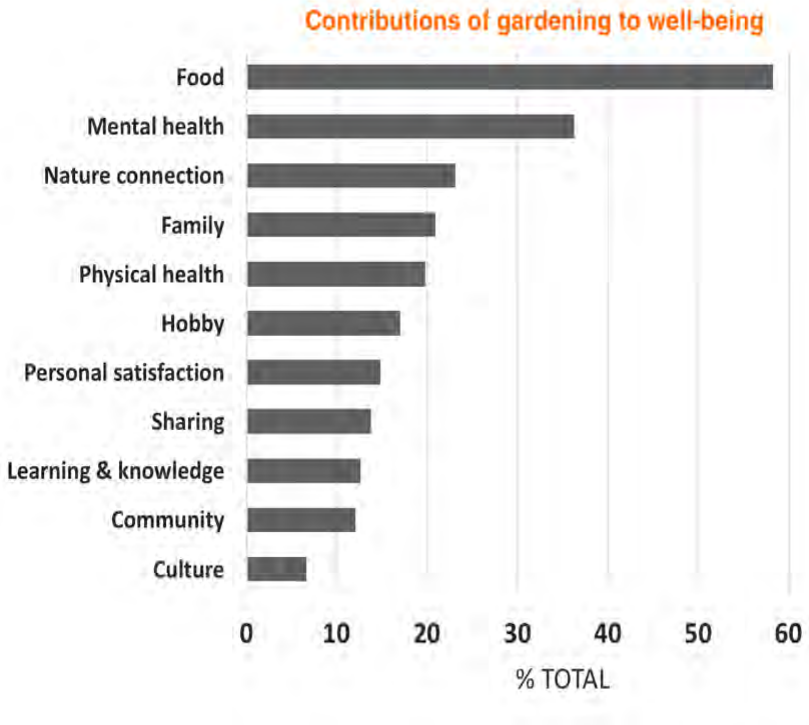
We completed surveys with 187 gardeners in 20 gardens. We asked questions about demographic backgrounds (age, gender, ethnicity, languages spoken, income), management practices (soil inputs, pest control methods, plants grown), levels of food security/insecurity, and motivations for and benefits gained from gardening. We thank all of the gardeners for taking the time to answer our survey questionnaire and share their gardening experiences with us!!

Here are some results. Gardeners are very diverse representing:

- 36 nationalities and 21 languages; 41% of gardeners are bilingual
- Age range from 22 – 91
- Income range from $0 to >$250,000
- Education ranges from no school to PhD

The gardeners surveyed grow >120 crops and >70 ornamentals; ***68% say they harvest between 5-10 lbs. of fruits and veggies per week; an additional 14% say they harvest >20 lbs. per week***. Unfortunately, despite large amounts of food harvested, ***many gardeners still suffer from food insecurity***. According to surveys, 60% of Latino gardeners, 21% of Asian gardeners and 10% of Caucasian gardeners suffer from food insecurity (don't have enough money to buy food, nutritious food, or skip meals). In addition food insecurity increases as income decreases; 50% of gardeners earning less than $40,000 per year, and 8% of gardeners earning between $40-$75,000 per year suffer from some level of food insecurity.

On the bright side, ***100% of gardeners surveyed report that gardening has improved the well-being of themselves or their families***. Gardeners reported a wide array of benefits from food and mental health benefits, to having a place to spend time with family. We found improvements in gardener well-being through gardening across social and biophysical landscape gradients. Gardeners are motivated by diverse reasons, varying from gardening in order to connect to nature, to gardening for improved food access, or to enhance time spent with family and friends. Gardeners that live in highly urban neighborhoods spend more time in gardens than gardeners who live in neighborhoods with more natural habitat. Moreover, gardeners that live in areas with little housing opportunity spend more time in gardens. You can read this research in depth here: http://www.mdpi.com/2071-1050/10/1/96 .



Thanks again for participating and for reading our report!

Fig. 7. Many members of the research team at the Valle Verde Garden in Watsonville. From L to R - Monika Egerer, Peter Bichier, Hamutahl Cohen, Heidi Liere, Zach Jordan, Carly Sanchez, Azucena Lucatero, Theresa Ong