CONSERVATION INNOVATION GRANTS

FINAL Progress Report

Grantee Name: Pollinator Partnership (P2)	
Project Title: Evaluating and Communication the Ecological and Economic Costs and benefits of Incorporating Pollinator and Other Beneficial Insect Floral Resource Strips into Vegetable Production System	
Agreement Number: NRCS 69-3A75-9-204	
Project Director: Laurie Davies Adams, Executive Director	
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Period Covered by Report: September 2009 through September 2012	
Project End Date: September 30, 2012	

A) Summarize the work performed during the project period covered by this report:

The work accomplished during this 3-year project happened in three states and is reported below (Arizona, Ohio, and Montana).

ARIZONA

While some non-native plants have been tested for their attractiveness to pollinators and natural enemies, few studies have evaluated the use of native plants for this purpose. Arizona has a vast variety of native perennials and annuals that are well adapted to the extreme local conditions of the Southwest, such as poor soil nutrients, low precipitation and high temperatures. Many of these are thought to be attractive to pollinators and natural enemies, but this has not been tested under irrigated agricultural and garden situations.

The scope of work in Arizona was to test native wildflower species to see which ones could be incorporated into agriculture and home gardens to increase pollination and natural enemy numbers. Four (4) non-native species, which are typically used in habitat management projects were compared with eight (8) species of Arizona native plants which may be as or more attractive to pollinators and natural enemies. We used the following criteria to select our plants:

1. native to Arizona
2. will grow within typical agricultural production conditions within Arizona
3. will bloom during the growing season (October to April), and
4. are thought to be attractive to pollinators and natural enemies.

The study took place at the Yuma Agriculture Center in Yuma, Arizona. Plants were tested in individual 1 m^2 plots which were arranged in a randomized complete block with four replicates of each plant. Each 1-m^2 plot was spaced 6 m apart with bare ground surrounding the plots. Seeds were purchased for annual plants and plugs were purchased for perennials to reduce establishment time. Irrigation was administered through furrows.

In both the winter and spring of 2012, the Arizona team grew twelve (12) different flowers to determine which pollinators and natural enemies were attracted to them. These plants are listed below:

<u>Native</u>
Baileya multiradiata- Desert Marigold
Eschscholzia californica ssp. *mexicana*- Mexican Gold Poppy
Lupinus arizonicus- Arizona Lupine
Penstemon parryi- Parry's Penstemon
Ratibida columnaris- Mexican Hat Cone flower
Melampodium leucanthum- Black Footed Daisy
Linum lewisii- Blue Flax
Gaillardia pulchella- Firewheel

<u>Non-native</u>
Anethum graveolens- Dill
Coriandrum sativum- Coriander
Fogopyrum esculentum- Buckwheat
Lobularia maritime- Sweet Alyssum

In the spring, flower plots were sampled once a week with yellow pan traps. Those insects were place in 95% ethanol and identification of the insects began May of 2012. More than 60 families of insects have been identified from the samples collected from the yellow pan traps.

MONTANA
The major objective for our Montana location was to document the insect pollinator assemblages within different agricultural settings, including small diversified horticultural farms, large farms with a lower diversity of crops and plant nurseries, in Gallatin County of southwest Montana. Gallatin County, with an area of nearly 7,000 square kilometers, contains a diverse agricultural landscape of both horticultural crops (including vegetables, small fruits, flowers, and ornamental plants), provided mainly by small-scale farms, and agronomic crops (primarily alfalfa, winter wheat, and other small grains), which comprise the majority of large-scale agricultural production

Our Montana sampling sites fell within three categories chosen to maximize the range of plant assemblages sampled:

- Small-scale diversified farms growing a variety of fruits, vegetables, flowers, and herbs
- Nurseries growing a variety of bedding plants, perennials, trees and shrubs, and
- Large research farms growing various small grains and alfalfa.

These criteria increased the diversity of horticultural practice while allowing our team to sample pollinators within a small geographic area. The research farms gave us samples that can were compared to the more diverse horticultural crop production sites, and therefore acted in lieu of true controls (which would have been difficult to set up in an observational study within such a diverse landscape).

The major Montana research activities accomplished during the project include:

- monitoring 2011 nesting tubes daily for emerged insects,
- pinning, labeling, sorting and identifying all of the emerged insects from 2011 trap nests,
- entering data from 2011 trap nest identifications into a spreadsheet for analyses, and
- identifying all of the wasps from 2011 pan trap samples to the level of genus.

OHIO

The purpose of this project was to compare the costs of installing and maintaining single-species annual and multi-species perennial floral strips in vegetable production systems with the ecological and economic benefits gained, and to translate this information for use by vegetable growers in diverse agricultural regions. As part of that process, regionally specific seed mixes were developed, the efficacy of the integration of native and managed pollinator programs were observed; and the effectiveness of planting for both biological control and pollinators was examined.

To date there have been two (2) summers of experiments. The overall goal of the project was to assess the amount of biocontrol and pollination services offered to the crop by natural enemies and pollinators, and to test if the addition of a non-native annual floral strip (sweet alyssum) and a native perennial strip (27 species mix) would have an effect on these level of these ecosystem services.

The following are activities accomplished during the summer of 2011:

- 12 sites were acquired; 6 grew 3 rows of sweet alyssum in a 10 x 200ft plot next to 4 rows of Gladiator pumpkins, and the other 6 sites maintained a mowed 10 x 200ft area next to the same size plot of Gladiator pumpkins. The farmers were not allowed to use insecticides on the research pumpkins or the floral strips.
- A biocontrol experiment was performed twice in June and July by gluing spotted cucumber beetle and squash bug eggs to brown and green carstock, respectively. The eggs were counted and left in the field for 48 hrs. Upon retrieval they were recounted and squash bug eggs were moved to a growth chamber to assess parasitism. We used percent of predation and parasitism as the measure of biocontrol.
- Another biocontrol experiment was performed twice in June and July by collecting the adults of spotted cucumber beetle, striped cucumber beetle and squash bug at each site. The search effort was given parameters; stop searching when any of the following occurred:
    - 30 of each cucumber beetle and 10 squash bugs were captured,
    - 45 minutes of continual searching had passed, or
    - every plant in the plot was thoroughly searched.
- These live insects were fed sliced cucumber and raised in a growth chamber for 8 days and then frozen in a -80 F freezer. Later, these were dissected to search for

developing and emerged parasitoids. We used percent of parasitism as a measure of biocontrol.

- The pollination experiment was performed in late July and throughout August and September when pumpkins were in peak bloom. Ben Phillips set up video cameras on 2 female and 2 male flowers and recorded bees throughout the pollination window between 6AM and 12PM. He also collected 3 female flowers in the plot every 2 hours (8AM, 10AM and 12PM) to assess how pollen transfer may vary throughout the pollination window along with the guild of pollinators. The time treatments reflected pollen deposition after 2, 4 and 6 hours, respectively. In addition, he marked another 3 female flowers at each time period and collected the mature fruit in October to assess seed set. The identity and number of the pollinators in the video were recorded, as well as the time each bee spent in the flower in the video, the number of pollen grains deposited on female flowers, and the number of seeds in mature pumpkins as measures of pollination service.
- The economic analysis was initiated in October of 2011 by sending out worksheets for the farmers to fill out detailing their inputs managing the pumpkin crop. Ben Phillips was able to recover all of the first year's econ data by March 2012.
- The sweet alyssum floral strips underperformed in 2011 as a result of a very wet spring preventing mechanical control of competing weeds. The perennial strips were mowed once per month throughout the summer to build their root mass for the 2012 field season.

The following are activities accomplished during the summer of 2011:

- One farmer bowed out after the first year and another grower was recruited. This was supposed to be the year for letting the perennial strips grow for our experiments. However, one farmer accidently destroyed his fallow perennial strip. In addition, the sweet alyssum trial was repeated and 2 sites were added to fill the replicates needed. In 2012 Ben Phillips ended up with 6 control sites, 2 sites with perennial treatment only, 3 sites with alyssum treatment only, and 3 sites with both alyssum and perennial treatments separated by at least 200 yards.
- The biocontrol experiments were repeated exactly as the previous summer.
- The pollination experiment was repeated with 2 changes:
    - the seed set portion of the experiment was dropped and more pollen reps were added.
    - Ben Phillips also decided to bag each female flower so that each flower was exposed to pollinators for 2 hours. We believe the pollen tube formation may have skewed 2011 data and decided that limiting the time in which a pollen grain sits on the stigma would make a cleaner sample.

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

We are very excited about the work we have accomplished over the past three years. As with any projects, there are many takeaways, both from successful and unanticipated lessons learned. Below are a few examples.

We accomplished a great deal with these projects. First, we established a clear interest on the part of Ohio pumpkin farmers in the importance of pollinating and beneficial insect borders in no-till fields. In addition, we held several outreach events specifically for pumpkin farmers, and each event was fully or over-subscribed.

Our results at this time suggest that perennial borders out performed annual borders. Despite the length of time needed to establish perennial borders, they are ultimately easier to establish because of the vagaries of weather that impact annuals significantly.

We presented our findings to peers and the academic and research community at three conferences and this impacted at least 100 individuals of high profile within the field. Interest in the project findings is high as we are providing one of the first field-tests of conservation practices for pollinators.

The three state-specific bee guides we produced for this project were reproduced and distributed to over 3000 people and as available for download online. These were used as tools by farmers as well as researchers to help them identify pollinators on their landscapes.

In Arizona, we discovered a vast quantity of pollinator species were attracted to our sites. Our addendum in August should reveal more specifics about their makeup and plant preferences.

In Ohio, the extreme rainfall and subsequent drought confirmed the difficultly of border development in rain-fed agricultural systems. Planning for NRCS incentives needs to consider costs of regular irrigation as a supplement to establish beneficial insect habitat.

Cost-benefit analysis consistency is also difficult to establish when dealing with even the differences within the northern and southern parts of one state. Compelling numbers will hopefully emerge in our addendum as we will be examining mostly similar operations within the pumpkin industry.

Erik Norman and his research assistant, Patrick Karabon, analyzed the yield data from the 2011 field season. They analyzed the data several different ways. First they compared the benefits (revenues) and costs in a simple benefit-cost analysis. No clear picture emerged from the data due to the high level of variance among farms. They also analyzed the data by ranking them in terms of revenue, coding for the presence of floral strips. No statistically significant difference was found. They used regression analysis to control for some of the external factors (for example, northern vs. southern Ohio), but were unable to find a statistically significant difference in revenue among farms with and without floral strips. The weather was highly erratic that year and this added a lot of ambiguity to the data. Having an additional field season to work with should focus the results of this data analysis.

As these past two years have had significant weather and climate conditions, weather issues ranged from too hot to too cold temperature ranges where nothing would grow, to the lack of water, where our field staff had to hand water each field site. This increased the amount of money and time spent at each Ohio field site tremendously.

Additionally, it is difficult to anticipate how many samples would be collected at any given site. With this particular project, we found that we were able to collect many more insects than initially anticipated (for example, our Arizona team collected approximately 40,000 insects). Although these are solid data points which will ultimately help with the analysis of the data, it has taken us much longer to identify each of the collected insects than anticipated.

In the future, we will incorporate more time (for field season time in case unpredictable issues arise with the climate/weather), and resources (to help with insect identification).

C) Describe the work that you anticipate completing in the next six-month period:

The Pollinator Partnership will continue to work on this very important pollinator research. We have secured partners to help continue to supply the financial resources needed to further analyze the vast amount of data collected from this project.

To benefit NRCS and further our pollinator knowledge to apply these findings, we will keep NRCS apprised of our progress with an addendum to this final report. We anticipate producing this addendum by August of 2013.

We are grateful for this wonderful partnership and opportunity to work together on pollinator health. These data will help communicate the ecological and economic costs and benefits of incorporating pollinator and other beneficial insect floral resources strips into vegetable production systems.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;
2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.
3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

N/A

SUPPORTING MATERIALS

All these materials are available to download on this unpublished URL link on the Pollinator Partnership website - http://pollinator.org/CIG2009finalreportappendix.htm

NRCS CIG Conference Call Notes

- As 1 PDF from 2009-2012

Techniques/Data

- Collecting and measuring pollen grains instructional YouTube video by Ben Phillip: http://www.youtube.com/watch?v=4q46NfC30pY
- MT trap nest data 2010 – 1
- MT trap nest data 2010 – 2
- OSU vegetable evaluation summary 2011
- Pollinator cost-revenue spreadsheet template

Bee Identification Guides

- Arizona
- Montana
- Ohio

Posters/Conferences

- Landscape effects observed on biocontrol of pests in Ohio pumpkin crops, Entomological Society of America (ESA) PPT presentation by Ben Phillips
- Quantifying the pollination service supplied to pumpkins (*Cucurbita pepo*) by multiple bee species in Ohio ESA 2010 poster presentation by Ben Phillips
- Habitat additions and the effects observed on natural enemies and pests in Ohio pumpkin crops, 2012 Ecosummit Poster by Ben Phillips
- MT Pollinator Research Update-2010, PPT by Casey M. Delphia and Kevin M. O'Neill
- Ag Excellence – Our Casey Delphia's work is highlighted on page 18 of this magazine
- Ohio 2010 pollinator and seeding experiment summary, by Ben Phillips, Scott Prajzner, Mary Gardiner
- AZ Native Arizona Wild Flowers in Agroecosystems PPT by Stacey Bealmear

Location Photos

- Ohio location photos
    - Ben and Scott at information table
    - Ben giving teacher pollinator poster
    - Ben with teacher at pumpkin seminar

- Crops-1
- Crops-2
- Crops-3
- Hedgerow-1
- Hedgerow-2
- Hedgerow-3
- Hedgerow-4
- Milkweed
- PanTrap
- Sampling-1
- Sampling-2
- Sampling-3
- Sampling-4
- Scott distributing pesticide guides
- Wildflowers-1
- Wildflowers-2
- Wildflowers-3
- Wildflowers-4

The Pollinator Partnership would like to thank the USDA Natural Resources Conservation Service for their support in this project. We greatly enjoyed this partnership and are hopeful that this project will result in greatly increasing pollinator populations in the United States.