Final Project Report
Conservation Innovation Grant
The Xerces Society

Grant agreement between the United States Department of Agriculture Natural Resources Conservation Service and the Xerces Society, Inc.

PROJECT: Develop and Test Pollinator Habitat Job Sheets for Six Regions of the United States

PRINCIPLE INVESTIGATORS: Scott Black, Executive Director; Mace Vaughan, Pollinator Program Director; Eric Mader, Assistant Pollinator Program Director

TIMEFRAME: September 24, 2009 – June 30, 2013

CONTRACT AMOUNT: $255,312

GRANT NUMBER: NRCS 69-3A75-9-131

DATE OF SUBMISSION: July 2013

DELIVERABLES IDENTIFIED IN THE GRANT AGREEMENT:

- Pollinator plant list refined for agricultural setting and specific crops (i.e., bee focused, screened for availability, and potential to harbor crop pests/diseases).
- Specification or job sheets for implementing pollinator conservation projects in six regions across the country.
- Field trials of pollinators project specifications.
- Field verification of bloom time of plants on pollinator plant lists.
- Workshops and net-meetings to disseminate project results to conservation planners.
- Attend at least one NRCS CIG Showcase or comparable NRCS event during the period of the grant.

TABLE OF CONTENTS

INTRODUCTION

With funding from this Conservation Innovation Grant, the Xerces Society worked with partners and growers in six regions of the country to develop and test pollinator habitat specifications and installation instructions that support specific bee-pollinated crops. In each of these six regions, we conducted field trials of these project specifications and then used project results to revise our implementation protocols. The final products we developed are job sheets and installation guides (in some cases now called Specifications and Implementation Requirements) that include plant lists and other recommendations for site preparation, planting, and follow-up weed management specific to each region.

The project also included an outreach component to distribute the information developed to conservation planners in each of the six regions. To accomplish this, Xerces organized a minimum of two webinars, workshops, and/or field days in each region during the project. The bulk of this outreach occurred the final two years of the three-year project.

During the first two years of this project, we worked with partners in each of the six areas to create region-specific project plans, identify local demonstration sites, and prepare sites for planting. We and our partners planted most of the sites in the fall of 2010, and they were monitored for the duration of the project.

During the last year of the project, we worked to draft regionally tailored job sheets and installation guides for creating successful habitat enhancements using the Conservation Cover and/or Hedgerow practice standards in nearly all regions where major bee pollinated crops are grown. These job sheets and corresponding trainings will provide technology transfer between the project results and end users at the state and field office level nationwide. Drafts of these guides were presented at a poster session and at a workshop at the 2012 annual meeting of the Soil and Water Conservation Society in Fort Worth, Texas.

These components resulted in a total project cost of $520,987, of which $255,312 of Federal Conservation Innovation Grant funds were requested. All Federal funds were matched with non-Federal sources ($265,675). All funds were spent as anticipated, however, in the summer of 2012, we requested a no-cost extension to complete project deliverables. Aside from the single extension request, all key goals and objectives were met or exceeded.

BACKGROUND

Pollinators are essential to our environment. The ecological service they provide is necessary for the reproduction of nearly 75 percent of the world's flowering plants. This includes more than two-thirds of the world's crop species. The fruit, seed, and animal (meat and dairy) production supported by pollinators provides over 30 percent of the foods and beverages that we consume. The annual economic value of insect-pollinated crops in the United States was estimated to be $20 billion in 2000, with native insects contributing at least $3 billion.

In 2006, the National Research Council (NRC) of the National Academy of Sciences released the report *Status of Pollinators in North America*, which called attention to the decline of pollinators resulting from habitat loss, alteration, and fragmentation, as well as pesticide use. The report urged non-profit organizations to collaborate with landowners and agencies to publicize activities that promote and sustain these important insects. The NRC report specifically cited the Xerces Society as an example of such a non-profit organization.

Honey bees provide the bulk of crop pollination in the U.S., yet the number of managed honey bee hives has declined by 50% since the 1950s. Each year, the U.S. beekeeping industry loses more than 30% of hives from a variety of problems, including diseases, pests, and Colony Collapse Disorder. Recent research on crop pollination, however, has demonstrated that native bees also make a significant contribution to crop pollination—in some cases providing all of the pollination required when enough habitat is available. Today, habitat supporting these native pollinators is more important than ever as honey bee hives become more expensive and difficult to acquire. Furthermore, research suggests that increased pollen diversity leads to higher fitness in honey bees; diverse wildflower plantings benefit honey bees, as well as native species.

The 2008 Farm Bill includes pollinators as a priority resource concern for USDA conservation programs. To successfully implement pollinator conservation projects, farmers and NRCS conservation planners need detailed specifications for different regions of the country. Currently, we understand the plant composition needed to support a diverse and abundant community of pollinators. However, feedback from individual growers, grower organizations, Cooperative Extension agents, and NRCS/SWCD conservation planners across the country (through personal interviews and on-line surveys) shows us that there is a lack of specific information on how to establish plantings that contain diverse wildflowers.

Specifically, growing monocultures of native grasses is comparatively simple, where broad-leaf herbicides are available to help with weed control. When establishing diverse wildflower meadows, growers have fewer weed control tools, making site preparation (e.g. weed abatement) very important. Also important are the regional differences in habitat establishment. Weed pressure and planting methods in the Midwest prairie states, New England, the Southeast, Pacific Northwest and California can differ, sometimes significantly. This range of conditions highlights the need to develop regional approaches to habitat establishment.

Conservationists and growers also have concerns about establishing habitat that is able to sustain diverse shrub and wildflower communities over time. Plans and field trials are needed across the country to document effective ways of managing long-term pollinator plantings.

Finally, while growers support the idea of conserving pollinator habitat, they are also concerned about bloom competition between target crops and habitat plantings, the potential for plantings to become weeds in the main crop, or for these plantings to harbor crop pests or diseases. Therefore, it is important to develop job sheets and plant lists around specific crops that take into account what is known about diseases and pests, and that minimize floral competition with the primary crop.

REVIEW OF METHODS

In each of the target regions, we worked with project partners, including agricultural producers, universities, conservation districts, NRCS state offices, and PMCs, to:

1. Refine plant lists. We took current eco-regional or state plant lists and focused these down to at least two lists appropriate for an agricultural landscape. The first list we refined for each region documented agricultural-appropriate species that were currently available from native plant nurseries or seed companies and which were suitable as general bee habitat. The second list focused on either a specific crop, a specific ecosystem need (e.g. for wet sites), or a specific conservation need (e.g. an inexpensive seed mix or non-native alternative). The crop-specific list reflected the need to supply flowers outside of the primary crop bloom period, and plants were vetted for their potential to harbor pests and diseases that could negatively affect the adjacent crop. We developed at least one crop-specific list for most regions. If there were plants that provided good bee forage but were not yet readily available, we brought these to the attention of the PMC and nursery industry leaders.

Pollinator Plant List Selection Protocol: When we developed pollinator plant lists, we emphasized commercially available native species. We also supported the use of non-invasive introduced species with specific agricultural utility (cover crops, field buffer strips, etc.). Non-invasive introduced species were also recommended for permanent plantings where native plant materials were unavailable or prohibitively expensive. Master plant lists included critical cultural data, including such information as life cycle (e.g. perennial vs. annual), size, moisture requirements, growth habit, and specific details on establishment or pollinator value.

2. Develop specifications for project implementation. We used the general and crop-specific plant lists we refined to develop specifications on how to successfully establish diverse plant mixes in each region. These specifications addressed site preparation and weed management, which are much more difficult for wildflower plantings where broadleaf herbicides cannot be used. The tools and techniques available also varied among different ecoregions and soil types.

3. Conduct field trials to test planting specifications. The specifications were tested in *at least* two sites in each region: one local EQIP-eligible grower and at an area PMC. EQIP growers were identified by our NRCS, conservation district, or university partners. We worked with each grower on a site plan and helped ensure that the site preparation and planting were done in accordance with our specifications.

4. Monitor field trials. After implementation, PMC staff monitored bloom period for each plant. For the field trials conducted with EQIP growers, each grower and/or our conservation partners documented bloom period over at least two years to ensure that our plant choices were blooming at the appropriate time relative to the primary crop. We worked with partners to develop a flower monitoring protocol and data collection sheets.

5. Revise specifications based on input from field trials. Experience gained in implementing each project was reviewed and used to update the original specifications in order to produce a job sheet (or equivalent publication) for at least two pollinator plant lists in each area. The job sheet

was geared towards producers and NRCS/SWCD conservation planners so that they have the specifications they need to efficiently plan and implement pollinator conservation projects.

6. Disseminate information to NRCS conservation planners and other agricultural professionals. We organized webinar/net-meetings, workshops, and/or field days in each region to teach conservation planners about these project specifications. Job sheets were shared through NRCS state technical staff and state conservation district associations.

DISCUSSION OF QUALITY ASSURANCE

As we developed methods, tools, and demonstrations, we solicited feedback from project and NRCS partners to make sure that the information we developed was most useful to the NRCS and farmers. These same partners were heavily involved in our restoration work and provided quality assurance across all regions.

FINDINGS

Specific work performed over the course of the project period is summarized by each region below.

UPPER MIDWEST

In the Upper Midwest, we established four demonstration sites: a cranberry farm in central **Wisconsin**, an apple and fresh vegetable farm in southern **Wisconsin**, a cucumber farm in northeastern Wisconsin, and an organic fruit and vegetable farm in southeastern **Minnesota**. We worked with our partners at the University of Wisconsin's Center for Integrated Agricultural Systems and three farmers to prepare their sites appropriately for planting during the fall/winter of 2010-2011. In the spring of 2011, we began site preparation on the fourth site, a large-scale pickling cucumber farm in northeastern **Wisconsin**, which was planted in the fall of 2011.

Wisconsin Rapids, Wisconsin (Cranberry Farm)

The **cranberry farm** (John O'Day) prepared their site from June through mid-October 2010 with four glyphosate treatments. The site was then planted via frost seeding (by hand) in winter 2011 by University of Wisconsin partners and O'Day Cranberry Farm staff. At planting, the ground was frozen with approximately 1 to 2 inches of snow on parts of the field. A few days after seeding, the site received 6+ inches of snowfall and did not thaw until late April or early May 2011. Sand and vermiculite were mixed with the seed as a planting substrate.

During the spring, summer and early fall of 2011, the pollinator habitat was mowed frequently to control weeds from going to seed (every time weeds reached ~3-6 inches). Adjacent grassland areas were also mowed throughout the season to prevent weed seed from coming into the site.

Plant establishment and weed competition were monitored again during the 2012-growing season. In early spring of 2012, part of the site flooded for several weeks altering the plant composition, with fewer weeds and more desirable forbs surviving on the flooded portion. The

non-flooded areas exhibited extensive encroachment by red and white clover. To reduce clover from the planting area, we explored the possibility of flame-weeding the site. Some flame weeding occurred in November 2012, but we were unable to treat the whole site. Weather (high winds, rain and/or snow) precluded burning the remainder of the site in 2012. During the 2013 growing season we will try again to burn the clover patches and reseed wildflowers.

Stoughton, Wisconsin (Apple and Vegetable Farm)
The **apple and fresh vegetable farm** (Green's Orchard) in Southern Wisconsin prepared for planting by using repeated tillage from March through late September 2010 and a single application of glyphosate in early October 2010. The site was extremely wet most of the growing season in 2010, limiting further site preparation by the grower. The site appeared weed free in August and October of 2010.

This site was planted with support from the Agrecol Corporation in winter 2011 when the soil was completely frozen and covered with patches of snow 2-3 inches deep. Agrecol staff planted the site using hand-held seeders, mixing the seed with gypsum, vermiculite, and perlite as a substrate to ensure even distribution of the various sizes of seed in the mix. During spring, summer, and early fall of 2011, the site was mowed every time plants (mostly clover and weed grasses) reached 3-6 inches tall.

The site was monitored for plant establishment and weed growth again during the 2012 growing season. In 2012, more than half of the planting area is dominated by native forbs (although none were mature enough to flower). The far southern end of the planting area consists of a mix of native forbs and non-native clovers. As with the O'Day cranberry site (above), we recommended flame-weeding or winter application of herbicide (before perennials emerge in the spring) to reduce the amount of clover present.

Almond, Wisconsin (Cucumber Farm)
During 2010-2011, we also recruited a Wisconsin **cucurbit grower** (Warzynski Cucumbers). Beginning in mid-2011, the grower began site preparation on a ½-acre area for planting in fall 2011. The site preparation began with an application of glyphosate at the beginning of May 2011. The site was then vigorously tilled on May 14th. Additional tillage and glyphosate treatments were performed from May through August 2011. This site was seeded in early 2012.

No germination was observed on the site (which consists of deep sand soils) during the first half of the 2012 growing season, although no weed growth was observed either. In August 2012, with the first rains after the prolonged drought, many weeds germinated. These were mowed at 5 to 6 inches high in August and underneath many native wildflowers had also germinated. Additional germination of native wildflowers is expected after natural winter cold stratification and precipitation during the winter and spring of 2013. To take advantage of the sandy soil, we made the decision to supplement the planting area with additional seed of perennial lupine. Lupine serves as a host plant for the Federally endangered Karner blue butterfly which is present in the vicinity of the farm.

Southeastern, Minnesota (Organic Fruit and Vegetable)
Using leveraged (non-NRCS) funds, a fourth site, an **organic fruit and vegetable farm** (Hoch's

Orchard) in southeastern Minnesota, was recruited. We believe experiences gained at this site will provide valuable comparisons with the restoration process on conventional farms (where herbicide use is often a standard tool for pre-planting site preparation), and it will help us provide guidance to other organic producers in the creation of habitat areas.

Site preparation occurred during the 2010-growing season by tilling multiple times. At site inspection in April 2011, the soil was frozen but bare; no apparent weed or plant stubble was visible. Site planting occurred on May 4, 2011, which was later than optimal due to continuous snow, rain and windstorms until that time. The site was planted on semi-frozen ground. The grower cold stratified the seed by placing it in a freezer for a day or two and then taking them out for a day and then refreezing for a day or two, etc., for two weeks prior to planting (to mimic natural freeze-thaw actions).

In 2012, we saw initial establishment of the planted forb species along with re-emergence of cool season non-native grasses and legumes. The initial ratio of native to non-native vegetation is promising, however to reduce weed pressure, the site was mowed throughout the season, making a full assessment of success difficult. Additional monitoring is being conducted in 2013, and weed control strategies (including prescribed fire) are being considered.

Plant Lists

In the spring and summer of 2010, we worked with entomologists with the University of Wisconsin to evaluate pollinator plant lists for potential to host insect pests and diseases that could impact either apples or cranberries. University of Wisconsin staff discussed these findings with Xerces Society Assistant Pollinator Program Director Eric Mader and determined the best seed mix for each site. Partners at the University of Wisconsin also met with the Agrecol Corporation (a large, Wisconsin-based native seed producer) and reviewed the seed mixes with respect to Agrecol's data on suitability to proposed soil conditions.

In the fall of 2010 and winter of 2011, Xerces and University of Wisconsin partners finalized all plant lists for use in our field trials with apples and cranberries and conducted the final planting. Throughout the 2011 growing season, both sites were monitored to evaluate germination and mowed on a routine basis to control weed competition.

During early 2012, a third seed mix was developed that was customized to the soil and site conditions of our cucumber farm demonstration site in northeastern Wisconsin. Because pickling cucumbers are typically grown on extremely well drained sandy soils, deep-rooted species tolerant of those conditions were selected. Additional screening characteristics (such as weed potential) were also incorporated into the selection process.

Rose Lake NRCS Plant Materials Center

The NRCS Rose Lake Plant Materials Center (PMC) in East Lansing, Michigan services the state of Wisconsin and has been an important regional partner in supporting pollinator conservation efforts. We worked with the NRCS Rose Lake PMC staff to identify barriers to the adoption of pollinator restoration efforts in the Upper Midwest. While weed pressure was identified as an early challenge, deer browsing of new plantings emerged as another significant issue. Planting of a pollinator meadow from seed was conducted in summer 2010 as a follow-up

to the existing pollinator hedgerow demonstration at the PMC. Following these plantings, the PMC was able to install fencing around part of the planting area to exclude deer.

Midwest Outreach

On July 13, 2012, we conducted a full day short course at the University of Minnesota in Duluth, followed by a field tour of the University's heritage research orchard. More than 30 people attended the event including farmers and NRCS staff from across northern Minnesota.

In February 2012, Eric Mader and Jennifer Hopwood conducted multiple sessions on habitat restoration for pollinators at the Midwest Organic and Sustainable Education Service (MOSES) conference in LaCrosse, WI. More than 300 farmers and other agricultural professionals attended these sessions, which were supported by an informational booth in the main exhibit hall.

On February 25, 2011, Eric Mader gave a presentation at the annual MOSES conference in LaCrosse, WI on *Designing and Implementing Insect Habitat on Your Farm*, highlighting emerging results and experience from this project, as well as use of NRCS conservation programs to support implementation of pollinator habitat project. Over 200 farmers and agricultural specialists attended this 1.5-hour workshop.

We also provided outreach support to the Rose Lake PMC. We developed interpretive signage for their pollinator demonstration plantings and highlighted these efforts at a full day Pollinator Conservation Short Course on June 24th, 2010 in collaboration with PMC staff, researchers at Michigan State University, the MI NRCS, and the MI FSA. Funding for this training was provided by the USDA's Sustainable Agriculture Research and Education (SARE) Program and did not serve as match for this grant.

PENNSYLVANIA

Drs. David Biddinger, Ed Rajotte, and Ph.D. student Amanda Ritz at Penn State University teamed with Jim Gillis at PA NRCS and Xerces Society staff to identify farm areas appropriate for pollinator habitat enhancement and the testing of site establishment protocols. We developed four site preparation plans to determine which techniques are best-suited and most economical for Pennsylvania apple growers. One private landowner and two research farm sites were identified for testing these site preparation protocols. We also worked to refine plant lists that support tree fruit production, and we evaluated the long-term viability of 6 private owner pollinator planting sites that had been established in 2007 with support from the NRCS.

Plant Lists

Penn State University worked closely with PA NRCS, Xerces, and Ernst Conservation Seed (the largest native seed supplier in the region) to refine our plant list in support of *tree fruit* production. To date, the greatest interest in pollinator habitat projects in Pennsylvania comes from Adams County, the primary apple, peach, and cherry producing region of Pennsylvania. Since 2010, over 150 acres of pollinator plantings were established adjacent to apple orchards with almost 25 fruit growers through the CSP, EQIP, and WHIP programs.

Final plant lists were created in 2011 for wet and dry sites. These lists continued to be modified based on the availability of seed and continuing research into the natural history and effectiveness of the over 50 species of bees known to pollinate apples in Pennsylvania and New York from other research. Some of the modifications that have been made based on our experience have been to drop Blue Flax from the list since it is not very attractive to our bees and does not persist in the plots for more than a year or two. More emphasis has been placed on Monarda and the Asters since they compete well with weeds and are very attractive to bees. Partridge pea is now regarded as more of an initial flowering cover crop the first season to help reduce weed pressure, but it did not persist beyond the first year. Crimson clover was also not very persistent after the first season of planting.

Our plots in Pennsylvania also support our current recommendations for planting at 60 seeds per square foot (significantly higher than previous rates of around 25 seeds per square foot). For example, pollinator plantings created in 2007 were applied at only 2 lb/A of seed in the spring and by the 5th year (2012), few of the original flower species were still available to pollinators. With the higher 4 and 8 lb/A rates of seed and regular mowing, we believe the NRCS plantings from 2010 will persist for the 5-year life of the NRCS contract.

The plant lists still retain their focus on (a) providing blooming wild plants throughout the growing season and when a main insect-pollinated crop is not in bloom; (b) including species that will not become weeds in the primary crop; and (c) including species that will not serve as alternate hosts of crop pests and diseases. For tree fruit production, we are moving toward emphasizing earlier blooming species that will better support the pollinators of early blooming orchard crops. Most of the key pollinators of tree fruit are *Andrena* and *Osmia* species that are active only for about six weeks in the spring. Flowering plants that bloom later in the growing season are still retained in the pollinator seed mixes to support bumble bees, sweat bees and small carpenter bees – as well as honey bees – that are present throughout the spring, summer and fall. These bees also play a role in tree fruit pollination.

In the fall of 2010 and winter of 2011, Xerces worked with Ernst Conservation Seed and the PA NRCS to find substitutions for various wildflower plant species that they sold out of due to widespread interest in establishing pollinator habitat (consisting of approximately 150 acres on 20 farms in Adams and Centre Counties in the fall of 2010). That interest level on the part of local farmers is directly related to the outreach conducted through this project.

Field Trials

In the first year of this project, we set up four demonstration sites in two regions of Pennsylvania (Adams and Centre Counties) including three PSU research stations and one grower site. At all of these sites, we demonstrated weed abatement prior to planting with three herbicide applications applied across the growing season to eliminate perennial weeds, followed by a fall planting. At a subset of these field trails, we established replicated plots where we compared this rigorous site preparation strategy with techniques typically recommended by NRCS field staff in the past (e.g. spring application of broad spectrum herbicide followed by spring planting and/or the use of alternative herbicides). At replicated sites, we also field tested various seeding rates.

Details for each demonstration site are as follows:

1. *Replicated Treatment Plots at the PSU Fruit Research and Education Center (FREC) in Adams County*: a 1-acre area of 24 replicated 30' x 30' plots (8 treatments replicated three times each);
2. *Unreplicated Plot at FREC*: a 1-acre unreplicated plot;
3. *Unreplicated Plot at PSU Rock Springs Russell Larson Research & Education Center*: a 1-acre unreplicated plot in Centre County, PA; and
4. *Unreplicated Treatment Plots at Chow Farms*: two fields on property owned by a grower (Dr. Franklin Chow) in Center County, PA, where we established (a) approximately ¾ acre in unreplicated plots, and (b) an additional ½ acre of habitat planted in spring 2010.

At two of these restoration sites (*Replicated Treatment Plots at FREC* and at the *Unreplicated Treatment Plots at Franklin Chow Farms*), we used an approved PA-NRCS pollinator seed mix to demonstrate the efficacy of the following components of proposed restoration plans: (a) spring vs. fall planting, (b) higher seeding rates of 4 lb/A vs. 8 lb/A, (c) method of application (i.e. broadcast vs. drill), and (d) the use of selective herbicides.

Unfortunately, in the early fall of 2010, we lost our sites at the Chow property in Centre County because of poor seed germination and ineffective weed control in spring plantings. As a result, the landowner lost interest in the project. However, we still are working with more demonstration areas than we outlined in our proposal.

In the fall of 2010, we drilled and broadcasted seed into the appropriate plots in the replicated demonstration treatment plots at FREC. At the unreplicated plot at FREC, we conducted further weed abatement to eliminate persistent Virginia creeper and poison ivy. This required application of high doses of glyphosate in two applications made mid-summer and early fall of 2010. We then drilled pollinator seed into this unreplicated plot in November 2010.

The PSU Rock Springs unreplicated 1-acre site had the same challenges as the Chow farm. A bad batch of seed and lack of cold stratification meant the seed (other than partridge pea) did not begin to germinate until the fall. This led to excessive weed growth due to lack of competition from wild flowers, despite mowing twice in summer of 2010 at a height of 6 inches to eliminate annual weeds before they went to seed. Plans for this site in 2011 were to overspray this plot and start over because of the problems with germination and weed competition, but an evaluation in the spring showed much better germination and early season flower bloom than any of the other sites. This success may have been due to the mowing in 2010 that the other sites did not receive and which may have reduced weed competition. Also, seed that lay dormant in 2010 germinated much better after cold stratification in the winter and was better able to compete with weeds the spring of 2011.

Monitoring Bloom Period & Pollinator Visitation

Using the sites planted under this grant, as well as an additional site planted in 2010 at a third PSU research farm and six older private sites planted in 2007, we evaluated the floral preferences of bees. We used several collecting techniques and timed counts to measure the diversity, abundance, and phenology of bees collected over the 2009 to 2011 field seasons. This was compared to bee data collected in apple orchards and pumpkins through a concurrent USDA -

SCRI grant researching apple pollinators to determine if the bees coming to the pollinator strips were the same species as those pollinating apple orchards.

Early analysis indicates that of the 53 bee species found in the pollinator strips so far, only 22 are also found visiting apple flowers. Most of the early season bees pollinating apple and other tree fruit have not been found in the pollinator strips. This information is helping us to modify the current plant mix and add early blooming woody plants and more early blooming perennial wildflowers near orchards if they are to be most useful for crop production, as well as general bee conservation purposes.

Leveraging CIG pollinator project deliverables for additional benefit

Beneficial insect predator and parasitoid data also was collected from previously established pollinator strips and will be compared to the previous samples collected from orchards to see if the abundance and biodiversity of beneficial insects other than bees are enhanced with these pollinator strips. Limited sweep net sampling of previously established pollinator strips has shown high numbers of the orchard pest, tarnished plant bug, but not stink bug species that injure fruit. Whether pollinator strips serve as a nursery to build up pest populations that may disperse into adjacent crops or will serve as a more attractive 'trap' crop continue to be examined.

Data from 2010-11 show that overwintering brown marmorated stink bug (BMSB) adults are more heavily parasitized by native tachinid flies when nectar sources are available in the fall from plants like goldenrod, wild carrot, and butterfly bush. Native stink bug egg parasitoids from the family *Scelionidae* are also known to need nectar sources as adults in order to produce eggs. Thus, in the summer of 2012, we surveyed existing NRCS pollinator plantings to determine if stink bug parasitoids are visiting the flowers in the current mix or if we can modify the mix to enhance biological control. In 2012, we put out sentinel egg masses of BMSB within pollinator plantings and within apple orchards near the pollinator strips to see if egg parasitism is increased. [Note: this additional beneficial insect research is funded by a State Horticultural Association of Pennsylvania (SHAP) grant in collaboration with Professor John Tooker at PSU.]

Coordination with PA NRCS

We have worked very closely with the local and state PA NRCS staff to ensure that they are informed of project results and to ensure that these efforts best support their programs. This is especially important because of the large number of growers who enrolled in the pollinator enhancement under CSP (as well as a small number of pollinator buffer plantings under EQIP) in Adams County. The lessons learned under this CIG have already been used to support pollinator conservation on the ground.

Project partners at PSU have attended several PA technical committee meetings throughout 2010-11 to update the state NRCS on our progress and continue to work with NRCS at the local level. Most of the acres enrolled for pollinator habitat under CSP are using the research and demonstration option with PSU so that we can work directly with them to develop the best establishment practices and use these sites to collect additional pollinator diversity and utilization data.

In March of 2011, Mace Vaughan and Jolie Goldenetz-Dollar (Xerces Society Pollinator Habitat Restoration Specialist based out of Cape May, NJ) met with Dr. Biddinger, James Gillis (DC Adams County), and PA NRCS state technical and program leaders to provide updates on progress and make sure that current plans are coordinated with the needs of the state.

Pennsylvania Outreach
In March and April of 2011, we helped the PA NRCS Public Affairs specialist develop a brochure on bee conservation and NRCS programs and practices. Mace Vaughan provided editorial review of the draft content for the brochure and photos of native bees, nests, and flowers for the state office to consider including. To obtain a copy of this brochure, visit http://www.pa.nrcs.usda.gov/news/publications.html.

On June 23, 2011, Xerces, PSU, the PA NRCS state office, and the PA State Department of Agriculture organized a field tour of pollinator restoration sites around the PSU Fruit Research and Extension center in Biglerville, PA. In attendance were staff from the PA NRCS state office, including Denise Coleman (State Conservationist), Leonard Jordan (NRCS Eastern Region Conservationist), Gary Thompson (Dean for Research and Graduate Education, PSU School of Agriculture), and PA State Department of Agriculture staff (the Secretary of Agriculture had to cancel at the last minute because of a family emergency).

Xerces and PSU also leveraged funds from other grants to develop a video that highlighted the value of this project, connections to NRCS conservation programs, and how pollinator declines and challenges to the beekeeping industry are the core issues being addressed by these demonstrations and associated research . This video is available at http://extension.psu.edu/ipm/resources/native-pollinators and was unveiled during the June 23, 2011 field tour.

On July 13, 2011, Xerces staff partnered with PSU to conduct a field day about this research at the Fruit Research & Extension Center in Biglerville, PA. Approximately 150 growers and eight NRCS staff attended the event. Dr. Biddinger gave a talk about pollinator conservation in and around apple orchards and Xerces staff provided technical support and information. PSU and Xerces staff also led a tour of the pollinator habitat establishment test plots.

Finally, leveraging additional grant funding from the NE IPM Institute, Xerces and PSU collaborated with Cornell University to develop a Pennsylvania/New York publication on the value of native bees for apple pollination. The publication highlights the value of native bees, native plant habitat for supporting the pollination of apple, and helps connect orchardists to NRCS conservation programs. This publication was printed in April 2012.

NEW ENGLAND
In **New Hampshire**, during the first six months of this project, we worked with University of New Hampshire Cooperative Extension (UNH) and the New Hampshire NRCS to recruit two grower-partners: one is the state's largest low-bush blueberry producer and the other is a major heirloom apple producer and cider manufacturer. On each farm, we identified areas appropriate for habitat enhancement and created a restoration plan for those areas.

In addition to those farm sites, NH NRCS and UNH offered additional resources to work with us in the development of a third comparison planting at the UNH Research Farm in Durham, where a number of professional development events for farmers are hosted. This third site leverages CIG and matching funds and offers additional project replication in New England.

New Hampshire Blueberry Farm

The low-bush blueberry farm restoration site included a tornado-damaged woodlot that had been recently cleared by the landowner. To quickly address the loss of vegetation in the storm-impacted area, we worked with the landowner to identify native shrubs and forbs that were appropriate to local conditions, could stabilize and protect the soil, and which would benefit pollinators. Planting of the live flowering shrubs and re-seeding of bare ground areas with native forbs and grasses was initiated in late 2009.

Evaluation of the re-seeded areas in 2010 showed excellent establishment by shrubs and very good seed germination, with rapid establishment of various native pollinator plants like goldenrod, helenium, Joe-Pye weed, and purple milkweed. In addition to native plant restoration, the farm owner installed supplemental nest structures for native wood-nesting bees.

In the spring of 2010, non-CIG activities conducted by the blueberry farm came under review by the New Hampshire Department of Environmental Services. To avoid conflicts with the review process and to support full compliance with all relevant agencies, no further CIG activities were conducted until the review process was completed in early 2011.

In the winter of 2011, the blueberry farm partners were given approval to resume farm activities by the NH Department of Environmental Services, including full participation in the CIG project. Beginning in March 2011, we worked with the NH NRCS State Office to continue the project with ongoing plant establishment and weeding of previously planted areas. The plant establishment conducted in this phase included a continuation of shrub and live willow stake establishment, with an estimated 80% survival rate among all woody plants at the time of this reporting. Wildflowers (both planted and naturally occurring) continued to increase with the resumption of the project and routine weed management. Blue vervain, Joe Pye Weed, wild bergamot, mountain mint, and St. John’s wort produced abundant bloom during the summer of 2011. Despite the temporary delay in full project implementation, the participating landowners have been extremely pleased with the habitat enhancement project and remain deeply engaged. They report a significant increase in native bee populations since the project began. A final inter-seeding was conducted in late 2011 to maximize wildflower density.

An additional site review was conducted in spring 2012, revealing excellent ongoing establishment by the desired species. This provided direct benefits during the spring blueberry bloom period when rental honey bee hives where damaged by a bear. Sufficient native pollinator abundance on the farm allowed the producers to maintain pollination and crop yield levels on par with previous seasons. Some additional plant materials were established in 2012 to fill any gaps in the landscape, and additional plant monitoring are being conducted in 2013. To date, weed pressure at the site has been minimal.

New Hampshire Apple Orchard
At the New Hampshire apple orchard, several areas previously dominated by non-native grasses and serving no ecological or production value were selected for replacement with pollinator-friendly native wildflowers. Site preparation to remove those grasses (smooth brome, reed canary, orchard grass, and others) was conducted throughout spring and summer 2010 at three separate planting areas (totaling roughly 4 acres in size). In the fall of 2010, two of these sites were planted in an all-native seed mix consisting of 12 species planted at slightly over 10lbs/acre (roughly 45 seeds per square foot).

The third (and much larger) site was located away from the home farm and presented greater site preparation challenges where equipment is less readily available. Following a less intensive site preparation protocol, this area was seeded with a less expensive seed mix that included a lower-cost non-native pollinator plants (e.g. red clover), as well as less expensive, but aggressive native species, such as partridge pea and purple coneflower. The results of these plantings will be compared and help inform our recommendations to the NRCS and apple producers in the region. If effective, this approach may provide a lower cost alternative to strict native plant restoration in pasture and old field settings.

At our apple orchard site, in the spring and summer of 2011, we conducted initial monitoring for plant establishment, as well as routine post-planting weed management (especially mowing to prevent seed production by annual weeds). Based upon first year results, the areas seeded with higher value native plants (and where site preparation was more extensive) demonstrated excellent establishment. Species such as wild bergamot and aster were clearly present. The third area, with the low cost mix and less aggressive site preparation, showed good establishment of plants like red clover and partridge pea. While less ideal for supporting the full range of native biodiversity, this planting formula may be a useful compromise for providing pollinator habitat on farms with limited financial and equipment resources.

In 2012, the plantings at the home farm produced the first blooming plants, and demonstrated some of the best native forb establishment of any of our sites in the Eastern U.S. Despite drought conditions, the sites were dominated by beebalm, various asters, coneflower and other desired species, with only marginal weed encroachment by quackgrass. The sites were treated one time with a grass-selective herbicide and continued to thrive for the duration of the year. The third site (away from the home farm) was interseeded with a few additional low-cost forbs to increase floral diversity, and it is being monitored in 2013 for success.

Massachusetts Cranberry Farm
In Massachusetts, we worked with the Plymouth County Soil and Water Conservation District, the Cape Cod Cranberry Growers Association, and the Massachusetts NRCS to recruit an EQIP-eligible cranberry producer to participate in the project. We conducted initial site visits with this producer and the Conservation District in the spring of 2010. At this same time, we consulted with University of Massachusetts weed-control experts to develop a list of plants appropriate for habitat restoration on an upland site adjacent to a cranberry bog with well-drained sandy soils. The plant list is specifically designed to support populations of long-tongued bumble bees – which are important pollinators of cranberry – and to minimize the risk of weeds in the adjacent bog.

In follow-up meetings during the winter of 2010, we worked with the producer and SWCD conservationists to develop site preparation, planting, and weed abatement plans. The grower successfully implemented this site preparation between the late spring through early fall of 2010, applying glyphosate to the project site three times over the growing season.

Seeds were ordered for the site in late summer and a plan developed to sow the site using a hydro-seeder. Hydroseeding was chosen because the restoration site has very sandy soil and some of it is on a slope. We wanted to have a seeding mechanism that would allow us to apply the seed along with a mulch and ground cover to reduce the chance of erosion. However, hydroseeding is known to inhibit good seed-to-soil contact. To help mitigate this, the seed was hand-broadcasted prior to using the hydro-mulch. The mulch and tackifier were then sprayed over the top to help push the seed layer down and minimize erosion. We counted on snow to complete the contact between seed and soil. The site was seeded and mulched on a frigid December 6th and 7th, 2010.

During the spring and summer of 2011, the site was mowed with a string trimmer several times at boot height to prevent annual weeds from setting seed and to provide a competitive advantage to perennial wildflowers. We saw satisfactory germination over much of the site, although patches of ground with especially heavy layers of mulch seemed to retard germination. The primary weed of concern in early summer 2011 was nutsedge, which germinated across much of the site. The landowner hand pulled much of this weed to assist in the establishment of the native wildflowers during the mid-summer 2011. In May 2011, Xerces staff visited this site with partners from the SWCD, NRCS (state biologist), and University of Massachusetts cooperative extension researchers to look at plant establishment.

During the late-summer and fall of 2011, our partners at the Plymouth County Soil and Water Conservation District continued to monitor the project, documenting weed pressure and establishment. We had very successful establishment of partridge pea and dotted mint, but still had some weed pressure.

During the spring and summer of 2012, this site blossomed. During this period, the landowner performed almost no site maintenance or weeding. While there is still some weed pressure and an interest on the part of the grower and the SWCD to remove the use of little bluestem grass from the mix, the wildflowers we planted on site dominated. Monitoring by partners at the Plymouth SWCD demonstrated that most of the wildflower species we planted are present, and an August visit by Xerces staff showed significant cover of our species, including species that are slower to establish, such as mountain mint. One small area at the top of hill showed poor germination, so we purchased additional seed in September that was planted on this bald spot in November 2012.

Other Support to New England

In **New York**, we provided direct consulting to the NRCS Big Flats Plant Materials Center staff to conduct replicated plantings of wildflower species similar to those currently being used on farms in New Hampshire and Pennsylvania. Through this partnership, we (1) assisted PMC staff with the identification of previously unused high value plant species for pollinator habitat enhancements in the Northeast, (2) collaborated with them to develop strategies for site

preparation, seed acquisition, and planting, and (3) received feedback on the best germination and establishment protocols for the plant species being used in our restoration efforts.

In March 2011, we provided review and feedback to site establishment plans and timelines developed by the Big Flats NRCS PMC from earlier drafts of protocols Xerces developed for New England.

In August 2011, we worked with the Big Flats Plant Materials Specialist to provide photo documentation of pollinator plantings for inclusion in a guide to Critical Areas Planting and Conservation Cover practice standards.

New England Outreach

In September 2010, we held a full day Pollinator Conservation Short Course at the Big Flats PMC. Over 100 people attended, along with guest speakers from Cornell University who discussed their work on habitat conservation for pollinators around New York apple orchards and cucurbit fields. This training was funded by the USDA-SARE program.

On July 7, 2011, Mace Vaughan and Jolie Goldenetz-Dollar (Xerces Society) conducted a field tour in collaboration with the Plymouth SWCD. We visited pollinator conservation projects at our cranberry bog site and the Manoment Center for Conservation Studies' organic farm and discussed opportunities for more habitat creation around organic farms. The 15 tour participants included the MA NRCS state biologist, leadership at the Plymouth SWCD, and local farmers.

On December 7, 2011, Jolie Goldenetz Dollar (Xerces Society) participated in the Plymouth County Conservation District Annual Meeting and Election of Supervisors. Over 60 local conservation district supervisors and employees, NRCS staff, and farmers attended and hear her give a 30 minute talk to about pollinator conservation and NRCS programs and practices.

On May 15, 2012, we held a full day Pollinator Conservation Short Course in Maine at the Maine Organic Farmers and Gardeners Association fairgrounds in Unity. The event was attended by nearly 100 people including many farmers and NRCS staff from across the state. This training was funded by the USDA-SARE program.

Also on May 15, 2012, we conducted an evening twilight talk to the New Hampshire apple growers association at a farm in Rochester, NH. Nearly 80 growers and grower family members attended the meeting along with UNH extension staff, and NRCS staff from the state office in Durham.

On August 24, 2012, Mace Vaughan collaborated with Anne Averill (University of Massachusetts) to give a hugely successful presentation to an audience of more than 40 cranberry growers, SWCD, NRCS, and researchers on the value of wild bees to cranberry production and the process by which we established the pollinator meadow at our cranberry bog site.

FLORIDA

In **Florida**, during fiscal year 2010, we worked with the staff of the NRCS Brooksville Plant Materials Center to develop a list of recommended pollinator plants for restoration efforts. This list includes both native shrub and wildflower species designed to complement the bloom times of key high value crops, notably southern highbush blueberries and watermelon. It also targets plant species that are available from local nurseries and seed companies.

In addition, we worked with PMC staff to develop effective low cost weed control strategies for restoration plantings, a critical factor due to the presence of many aggressive non-native weeds in the state of Florida. After considering several options, we chose to plant woody and herbaceous starts (plugs and one-gallon pots) into a geotextile groundcover.

These efforts at the PMC culminated in the mid-summer (2010) planting of a 300-foot by 12-foot demonstration hedgerow at the PMC. The cost and efficacy of this planting will be compared against blueberry farm pollinator habitat field trials at Straughn Farms in northeastern Florida prepared with herbicides and established from a combination of seeds and plugs.

In the fall of 2010 and winter of 2011, we finalized monitoring tools for PMC staff to use in documenting bloom time and plant establishment during the 2011-growing season. Based upon those monitoring observations, establishment has been almost completely successful, with little transplant mortality. A follow-up site assessment by Xerces staff in February 2012 again revealed ongoing establishment success, and active blooming by the early flowering species. Extensive photo documentation of the site has captured ongoing use of the plants by a wide diversity of butterfly and bee species, including use of the shrubs by *Habropoda laboriosa* (known as the Southeastern blueberry bee), a species of economic importance for berry crop production in the region.

Florida Blueberry Farm

In addition to our collaboration with the Brooksville PMC, we are working with Straughn Farms to implement two pollinator habitat projects compatible with blueberry production. Straughn Farms is the largest blueberry grower in Florida, and they also manage a large acreage of watermelon. Our original proposal called for developing habitat establishment guidelines to complement both blueberry production and watermelon production. However, after meeting with Straughn Farms (January 2010), we learned that significant changes are occurring within the watermelon industry in Florida. Specifically, watermelon growers must contend with fusarium wilt, which they have treated with the soil fumigant Methyl Bromide in the past. This chemical is being phased out, and growers are now relying on a 7-year crop rotation instead (i.e. in year one watermelon is grown, in year two, pasture is planted, and then for the next five years the land is used to graze cattle). As a result, farmers are not invested in a single farm site and have little interest in developing permanent pollinator habitat adjacent to watermelon.

Because of this change in watermelon production, we instead created two different scenarios for habitat creation adjacent to blueberry production: pollinator hedgerows and meadow plantings. In the spring of 2010, we worked with Straughn Farm to develop a project implementation plan.

In the fall of 2010 and winter of 2011, site preparation was performed at the site. After much

discussion, Straughn Farms constructed raised hills (using watermelon field-preparation equipment) with perennials planted on 1.5-foot centers in bedded rows with a thick layer of bark mulch. The rows are on 10 foot spacing, and between rows, an inexpensive pollinator seed mix is being used as a smother cover. The meadow is approximately two acres in size.

The hedgerow was planted along the north edge of this meadow, adjacent to the blueberry fields, and was established using one-gallon pots in ground cleared using herbicides.

Planting of both areas was originally scheduled for early March, however, because of cold weather and overcast skies, one of the native plant nurseries supplying plant materials had to shift their availability timeline to the middle of April. Installation occurred on April 19, 2011, with support from colleagues at the University of Florida. Despite extensive preparation efforts, Straughn Farms experienced an irrigation system breakdown on the planting day, which combined with unseasonably hot weather (90+ degrees), resulted in some plant mortality. While the irrigation system was repaired within 24 hours of planting, the small size of plant materials required us to wait several weeks before we could begin evaluating the extent of plant losses.

In summer 2011, we conducted several follow-up visits to Straughn Farms and inventoried surviving plants. For most species, losses turned out to be minimal (with a few species experiencing almost no mortality at all). Based upon this inventory, we ordered supplemental transplants of a few species, as well as additional cover crop seed for the between row areas. Supplemental planting happened in mid-September 2011. Throughout the summer, we also performed ongoing weed management within the planted rows.

In February 2012, we conducted a follow-up site assessment at Straughn Farms and found good survivorship among most transplanted species. Those plants that did not survive were replaced in March 2012 to ensure good coverage of the planting area. A final challenge now is to reduce weed growth in the between row areas. To achieve this, we conduct an aggressive weeding of the site in late spring 2012, followed by a heavy seeding of native annuals (such as partridge pea and coreopsis) to establish rapidly and smother any weed completion.

The landowners continue to be challenged with aggressive weeds on site during the summer and fall of 2012. While the mulch has helped to retard weed pressure, it is still a challenge on the raised beds, likely helped by the irrigation during establishment. Also, the area between the rows continues to harbor weeds even with aggressive smother cropping. To continue reducing weed pressure, we worked with the landowner to again hand-weed the site in November 2012, immediately after which we broadcast a cover crop rate of crimson clover over the site to impede any new weed growth. The site will be reassessed in January 2013, and demonstrated little crimson clover germination. This is a surprise and, after discussion with the landowner on planting methods, appears to have been caused by using the bucket of a bobcat to push the seed into the ground. Instead of pushing the seed in, it appears that much of the seed was scraped off of the site, as the best germination was in depressions in the soil where the blade would have passed overhead.

Florida Outreach

To highlight lessons learned in Florida, we held a full day Pollinator Conservation Short Course

nearby at the University of Florida in Gainesville on February 2nd, 2012. Over 50 people attended including staff from Straughn Farms, NRCS Plant Materials Specialists, and various farmers and conservation agency staff from across Florida. This training leveraged funding from the USDA-SARE program.

OREGON

In Oregon, we collaborated with the Oregon NRCS state office, Oregon State University, and the NRCS Corvallis Plant Materials Center to develop plant establishment protocols for pollinator meadow plantings and hedgerows. The focus of this effort at the PMC included demonstration of methods to prepare approximately 2 acres of ground for a pollinator meadow. Over the summer of 2010, weeds were cleared using three applications of a broad-spectrum herbicide, and plans were developed for planting demonstrations of 12 different wildflower species known to support pollinators and other beneficial insects.

In the fall of 2010, 45 plots (18 feet by 50 feet each) were designated and planted with three replicates of 15 treatments. Xerces Society, PMC, and state NRCS staff participated in the planting. Twelve of the treatments are single species blocks of plants known or suspected of providing excellent forage for pollinators. Three treatments are species mixes: (1) an early- to mid-season flowering mix, (2) a mid- to late-season flowering mix, and (3) a combination of all twelve plants. These sites were monitored for how effectively plants are established, reseed in ensuing years, and produce bloom through time.

In April 2011, we saw successful weed abatement and consistent germination in most of the plots. During the summer of 2011, PMC and OSU staff continued to monitor germination and establishment of the pollinator plots. Many species established well, although some (e.g. *Sidalcea*) seem to have been delayed by the unusually long, cold wet spring. Weeds (both perennial and annual) were abundant in most plots but not extremely competitive. PMC staff believe that they will drop out in time. To discourage weed growth, PMC staff mowed half of each plot (east to west) to assess mowing as a weed management strategy and to open the canopy for perennial wildflowers.

During the spring and summer of 2012, these plots continued to be monitored by PMC staff. The diverse mixes continued to establish well, although with significant pressure from the river lupine planted in the “early flowering” and “all species” mixes. A couple of species, such as the buckwheat, sidalcea and milkweed, showed very poor establishment, which was likely due in part to very wet and cold springs in 2011 and 2012.

By June of 2013, the plots with species mixes were most successful in establishing and outcompeting weeds. The “all species” mix performed best and most species that were planted were present, strong, and blooming.

Medford, Oregon (Pear Orchard)

We collaborated with the Vaughn Farm**,** an orchard and hay producer located in Central Point, Oregon, to develop a pollinator hedgerow and field border planting adjacent to his apple and pear orchards. Vaughn Farms removed from production approximately 24 feet by 500 feet of

marginal hay field for use in this demonstration planting. A site preparation plan was developed and approved in the spring of 2010. Over the summer of 2010, the site was treated twice with a broad-spectrum herbicide. Draft plant lists were created for the site and were vetted by local experts at Cooperative Extension and at native plant nurseries for their availability, weed potential, and potential for harboring pests and diseases of apples and pear. Of particular concern to the grower were Lygus bugs. Based on this feedback, a final list was developed.

In the early fall of 2010, plant materials were ordered from a variety of nurseries and native seed producers across the region. Finding a supplier of native plant materials for the Medford, OR region (southwestern Oregon) proved to be a challenging task. Woody plants and seeds were delivered to Vaughn Farm in October 2010. The producer, Ed Vaughn, also applied one more treatment of broad-spectrum herbicide in the fall – prior to planting – to knock back remaining weeds on the pollinator habitat. However, in general, weed abatement prior to planting was not as aggressive as we would have liked.

In November of 2010, Eric Mader from the Xerces Society traveled to Vaughn Farm to help lay out the woody plants for the hedgerow, put the plants in the ground, and lay down the mulch. A plan was developed for watering the shrubs to help minimize transplant shock. In January of 2011, the producer seeded the rest of the site.

In the winter of 2011, Xerces provided Vaughn Farm with data sheets and information on monitoring the establishment and bloom time of the plants incorporated into the habitat.
In July 2011, we worked with Vaughn Farm to conduct an extensive hand-weeding of the site. Based upon the less than full season site preparation conducted in 2010 (beginning in summer 2010 rather than in spring), we anticipated some residual weed competition. Indeed, several weeds, including Queen Anne's lace and buckhorn plantain, continued to persist at the site during early 2011. In all, over 7,000 square feet of the planting area was hand-weeded during a single day. We believe, based upon similar experiences elsewhere, that hand-weeding of these two key weeds tends to be relatively effective as a control strategy. After weeding, bare ground areas were inter-seeded with additional wildflowers to further reduce weed competition.
Based upon our evaluation of the project site, despite some weed pressure, plant establishment was extremely successful in the first year (estimated to be at least 75%, based upon the species observed from the original seed mix). Species such as California phacelia, scorpion weed, various lupines, California poppy, common madia, and Bolander's sunflower all successfully established and bloomed during 2011.

In March 2012, we conducted additional weeding at Vaughn Farms by spot spraying with an organic herbicide (Weed Pharm, 20% acetic acid) to control seedlings of buckhorn plantain and non-native clovers. The site was over-seeded with a few additional low-cost forb species to ensure good coverage by desirable plant species.

By July of 2012, the Vaughn Farm site shrubs continued to come in strong. However, the herbaceous plants on site were dominated by red clover, likely coming out of the seed bank as this site was planted adjacent to a hay field. To compensate, the producer mowed the site, hoping to reduce the clover, however, in the process, many of the native forbs were inadvertently removed. Given the temporary expectations for native forbs at the site anyway (they were

initially planted adjacent to newly transplanted shrubs which will eventually shade them out), we focused our remaining efforts on ensuring survival of the shrubs and development of a high quality mature hedgerow.

Gathering Together Farm

During the fall of 2010, we identified Gathering Together Farm (Philomath, OR)--an organic row crop (fresh market) farm in the Willamette Valley--as another site for habitat development in 2011. Gwendolyn Ellen from Oregon State University (OSU) Integrated Plant Protection Center (IPPC) has managed planning and implementation of this site. Following identification of a planting location, the site was cover cropped and covered in ground cloth. The site is located between row cropped vegetable plots and a grain field. It also runs adjacent to a slough, offering additional options for both wet and dry adapted plants. A planting plan was developed in the late summer of 2011.

On December 16 and 17, 2011, an approximately 300 X 12 foot hedgerow was planted. An 80 X 40 foot slough extending out from the middle of the hedgerow into the field was also planted. Ninety-five native shrubs were planted on 4-foot centers with a variety of 480 native forbs interspersed among them. A total of 575 plants were transplanted into 8-16 inches of leaf mulch. Part of the site had been tilled in June 2011, and the other part was fallow. The slough had a cover of water foxtail (*Aloepecuris geniculitus*) which was left and planted directly into.

The entire site was covered in horticultural cloth in August 2011 and taken off pre-plant in December. The hedgerow was 80-90 percent under or in standing water in January 2012 for about five days and has also experienced flooding and areas of standing water (perhaps a bit less than before, 60-70 percent) in April 2012.

Being able to extend the slough area out into the field was an added benefit. It enabled us to increase the diversity of the plantings, optimize on the naturally occurring water foxtail as a cover for the transplants, and increase the eco-tonal area of the hedgerow which has been shown to increase the diversity and number of beneficial insects that will utilize the hedgerow.

The hedgerow site was also used in a Farmscaping for Beneficials' (OSU, IPPC) farm walk exercise on mapping habitat on the farm. In August 2011, 16 participants broke into three groups and were sent to different sites on the farm to map the area and develop potential habitat plantings. One group was sent to the hedgerow site without knowing it was slated to be planted as a hedgerow, and top on the list of suggestions by the group was creation of a hedgerow.

In the summer of 2012, about seven truckloads of leaves were re-applied by four volunteers in the hedgerow after mowing in between the rows of shrubs and forbs. Several spots of reed canary grass imported by winter flood events were dug out by hand. Though the hedgerow sustained a healthy population of weeds (mostly carrot family, mayweeds, and bent and rye grass) there was good native forb cover and blossom. Percent blossom of target and weedy species is being studied at OSU in order to measure it from hedgerow establishment through at least another year. No maintenance was needed in the slough area. As of the end of October 2012 there is still an excellent cover (about 90%) of water foxtail in that area which has effectively

smothered out other weedy species and kept the area sufficiently moist for the wetland species to thrive and flower.

In the fall of 2012, twenty-eight shrubs were transplanted by six volunteers after rains began. Existing mulch was spread over the transplants where possible. Some hand weeding in the hedgerow was also done at this time.

Sturm Farm
In summer 2011, we initiated an additional habitat project with a mixed berry farm located in Corbett, OR at Sturm Farm. The planting area consists of a two-acre block within the center of the farm located underneath a high-tension power line utility right-of-way. Because of the need to maintain a clear open area for the utility company to perform routine tower maintenance, the area below the power lines cannot be planted with berry plants and thus has been maintained as weedy fallow ground. No woody plants will be used in the habitat enhancement at Sturm Farm so that the area can be mowed periodically to comply with utility company maintenance needs.

Working with Sturm Farm, we made multiple glyphosate applications to the planting area in late 2011 and early 2012. On March 23rd, 2012, we planted the site with wildflower seed and rolled it with a cultipacker. Monitoring was conducted to assess weed competition and wildflower germination over the next several months.

By summer 2012, the seeded forbs had germinated, and were becoming well established. Ongoing monitoring revealed some initial weed competition, but excellent germination by species such as Oregon sunshine, various lupines, and gilia. Based upon these initial results, the producer is now going ahead with additional pollinator plantings on three other farms they own across Western Oregon.

Visits to this site in the spring of 2013 showed successful establishment of most of the wildflowers planted on site.

Omeg Orchards
We continued to provide technical support to Omeg Orchards on the management and expansion of a 2-acre pollinator habitat planting in The Dalles, Oregon. Throughout 2010, the plantings were challenged by bindweed. In September 2010, Xerces Society experts and the OR NRCS Plant Materials Specialist visited Omeg Orchards to provide advice on adding more wildflowers and managing the bindweed problem. Throughout the summer of 2011, bindweed control efforts were fairly successful, and weed pressure was reduced greatly.

North Willamette Research and Extension Center
Working with our project partners at Oregon State University (OSU), we completed a demonstration pollinator habitat planting around an organic blueberry plot at the OSU North Willamette Research and Extension Center. Site preparation was conducted for this planting prior to the start of this project, but the methods were well suited for our needs. The bulk of the planting surrounding the center's organic blueberry plot was organized by Gwendolyn Ellen of OSU's IPPC and occurred in November 2009. Site preparation included two full growing

seasons of tillage conducted at roughly 6-week intervals during the growing season. This site was monitored for bloom time and pollinator visits to flowers in the summer of 2010.

Oregon Outreach
On July 14th 2011, we conducted a public field day at the North Willamette Research Center in partnership with Oregon State University Extension for local tree fruit producers. Twenty-five local producers toured the site along with local Farm Service Agency and NRCS staff.

On June 20, 2012, Eric Mader (Xerces Society) collaborated with the Corvallis NRCS PMC and Oregon State University to lead an extensive tour of CIG-supported forb plots and earlier-established pollinator hedgerow as part of the 4th Annual Farmscaping with Native Plants Field Day. Content for this field day focused on identification of beneficial insects and habitat, and the pollinator habitat establishment techniques we have refined as part of this CIG grant.

On August 9, 2012, we led a field day at our Vaughn Farm site with a class of 50 students from Evergreen State College's Practice of Sustainable Agriculture Program. Ed Vaughn talked about the conservation practices he utilizes on his farm and Xerces staff explained the goals of the pollinator habitat planting and made the point that the planting also provides resources for (non-pollinator) beneficial insects that play a role in conservation biocontrol. Ed and Xerces staff talked to the students and answered their questions for about an hour.

On August 10, 2012, our partners at Oregon State University gave the same class from Evergreen State College a tour of our pollinator hedgerow project at Gathering Together Farm outside of Corvallis.

In October 2012, five Oregon State University (OSU) Geosciences students interested in agricultural/food sustainability issues also toured the Gathering Together Farm hedgerow while participating in an agricultural biodiversity tour. These students also helped transplant replacement shrubs and hand-weed the hedgerow.

CALIFORNIA
In California, we worked with partners at the NRCS, the California Association of Resource Conservation Districts (CARCD), and with several county Resource Conservation Districts (RCDs) to find project sites and to develop and implement pollinator habitat conservation plans.

Glenn County, California (Ranch)
A pollinator habitat demonstration site was planted in Glenn County in January 2010. This planting was conducted on non-irrigated rangeland and consisted of a ½ acre (100’ x 200’) planting of native wildflowers (‘forb mix’) and a clover / alfalfa (‘rangeland mix’). The two different mixes were planted in alternating strips (each strip approximately ten feet wide) throughout the ½ acre site.

A majority of preparation work for this site was done prior to the initiation of this project because the landowner was already working on a 40 acre EQIP rangeland restoration project on a larger piece of land to which this ½ acre pollinator demonstration site was added. Overall site

preparation began in the spring of 2008 with an herbicide application. The site was then chiseled and disked several times between the spring of 2009 and late fall of 2009. The primary partner on this site is the Glenn County Resource Conservation District, in collaboration with the NRCS.

The wildflowers and forage legumes produced abundant bloom in spring and early summer of 2010. We had significant problems with yellow star thistle on this site in the summer of 2010. We addressed this annual weed by mowing the site before it went to bloom and then turning cattle out to feed on the thistle for a few days. The site management appeared to be very successful with native gum plant (*Grindelia camporum*) continuing to establish itself and bloom after the mowing and grazing.

In the fall of 2010 and winter of 2011, Xerces Society's project manager met with the local NRCS, RCD, Cooperative Extension, and the landowner to develop a long-term plan for managing the site for the persistence of wildflowers while still maintaining use of the site for cattle forage. The results of this demonstration will be very useful for pollinator-friendly range management across California's Central Valley. The decision was made to tightly control access of cattle to the demonstration plot to help ensure that cattle would feed primarily on grasses and not be allowed to stay so long as to switch from grass to wildflowers. The landowner experimented with a portable electric fence to exclude grazing; however, there were logistical problems that still need to be addressed for this system to work.

From February to October in 2010, the RCD continued their monitoring of the site. The year after the star thistle management, the RCD documented successful germination of early blooming wildflowers in February 2011. Early in the 2011 season, the site was dominated by clover from the adjacent range planting (i.e. the site was originally planted in alternating strips of rangeland legumes and native wildflowers). Under the current grazing plan, the landowner tried to suppress the growth of the clover, but cattle didn't seem to prefer it.

Throughout the spring and summer of 2011, we saw dense germination of wildflower and forage legumes and consistent bloom throughout the site. Despite less diversity than we had anticipated, germination of certain species was dense and re-establishment of star thistle minimal. Management requirements of this site have been minimal throughout this time period. Cattle were excluded from the site for a majority of the summer in order to promote maximum wildflower bloom and establishment, but they were later allowed to graze the site to reduce the biomass of spent wildflowers.

In order to increase wildflower species diversity, we mowed the site in the fall of 2011 to prevent dominant species (e.g. late-flowering Grindelia) from setting seed. However, the staggered blooming and seed production of the dominant species made the timing of the mowing challenging.

We used a native seed drill to inter-seed the entire ½ acre site in the fall of 2011 with a diverse mix of native pollinator wildflower seed, to increase seed and floral diversity. We also plug-planted several hundred seedlings of the perennial Aster, *Symphyotrichum chilense*. Unfortunately, due to the severe winter drought, these transplants did not survive. Cattle were excluded from the site to allow for new plants to become established.

Initially, there was decent germination of early spring wildflower species. However, density was generally low, possibly due to the drought. In mid to late spring, the existing wildflower species began to get out-competed by the grass from the rangeland mix that was planted in adjacent strips. In order to reduce the competition from the grasses, cattle were brought onto the site to graze. Although the cattle did eat the grasses down and did not appear to be eating the forbs, this management technique may have been employed a little too late in the season to be effective. Additionally, the overall stocking rate of the area may have been too high, including the presence of a number of horses, which may have prevented successful establishment of summer wildflower species. Plant monitoring has been consistent and ongoing throughout the project.

San Diego County (Avocado Orchard)
During the first year of this project, we worked with staff from the Mission RCD in San Diego County to identify possible sites. Xerces staff met with the Mission RCD staff in early March 2010 to discuss the project and identified a local avocado and exotic fruit and nut grower who agreed to participate in the project. The project consists of several hedgerows with both large and smaller shrubs and a wildflower cover-crop area in the orchard interior. The landowner wanted the pollinator habitat to include flowers in bloom throughout the year but NOT from late March to mid-April to avoid any perceived competition with the bloom time of his avocado and macadamia trees. We worked with county extension services on plant selection to avoid choosing any plants that would be alternate hosts for crop pests or diseases. Plants were ordered and a November 2010 date was set for planting.

In late spring 2010, the landowner tilled the site to be planted into pollinator habitat. He then watered the site on a monthly basis and applied herbicides each time the weeds germinated. This continued until the November 2010 planting date.

In the fall of 2010, the hedgerows and wildflowers were planted on November 17 and 18. These plantings consisted of three different linear hedgerows totaling 3,375ft2. The hedgerows included a mix of shrubs, sub-shrubs, and grasses planted from container stock. A total of 120 plants, including 19 different species, were planted and drip irrigation was set up. In March 2011, most of the plants looked healthy. In the early spring 2011, some weeds germinated, but the hedgerow site was thoroughly weeded in mid-March, and the plants were top-mulched with compost. This technique has been very effective in keeping the weed pressure at a minimum. Monitoring of the hedgerow plants was consistent throughout the spring and summer of 2011. Overall, plant establishment and health has been very good, especially once the mulch was applied and the drip irrigation installed.

The wildflower planting consisted of three different areas, totaling 1,125ft2. We planted three different wildflower mixes at the site, with an overall total of ten different wildflower species. The mixes were broken out into groups of three or four species that bloom at different times. To establish these areas, the site was seeded by broadcasting with a belly-grinder for larger seed and a kitchen colander for smaller seed (mixed with polenta cornmeal). After spreading seed, the area was raked lightly and irrigated immediately after planting using an overhead sprinkler. In addition, a floating row cover was laid on top after seeding to protect against seed predation.

Monitoring of the wildflower planting in March of 2011 demonstrated that early germination was mixed. The early blooming species look good, but there was no sign of later blooming species. This is to be expected. We anticipated that we would need to weed the area where later blooming species were planted.

Monitoring of the site continued throughout the spring and summer of 2011 consistently. Forb establishment in the wildflower areas was mixed. The early-to-mid blooming forb mix was very prolific, but the later blooming mixes yielded minimal germination and bloom. Weed competition likely played a role in the poor establishment of later blooming forbs. Although weed management was conducted in the forb plots, it was not completed until early summer, at which point the weeds had likely out-competed the wildflowers. One of the reasons for this delay was that the farm laborer was not familiar with the species in the forb mixes, so he was unable to weed the plots on his own and had to wait for assistance from our local RCD partners.

In the fall of 2011, we re-seeded the areas that had poor germination with a diverse mix of native wildflowers. Because of the heavy competition of winter and early spring annual weed species, we did not seed with the seasonal mixes used last year but developed a new mix. The species composition for the new mix was guided by the monitoring data collected last year and was designed to have more even germination and bloom throughout the season. Weed competition and site maintenance continued to be a challenge but was better overall after the re-planting. Plant monitoring was consistent through the fall of 2012.

Santa Cruz County (Diversified Organic Farm)
We worked with the Santa Cruz RCD to identify a project site in Santa Cruz County. This is an organic farm that grows a diversity of different crops, including pollinator-dependent raspberries and kiwis. Because these crops are grown in small blocks scattered throughout the farm, four smaller sites were planted into pollinator habitat rather than a single hedgerow or meadow.

The plan was to prepare the site through a mix of hand-weeding, repeated cultivation, and mulching (smothering) with straw (Note: it appeared that the landowner did not follow the rigorous plan of repeated cultivation to which he agreed, and the straw smothering never happened).

The planting itself consists of wildflowers plug-planted into old strawberry beds and a number of hedgerows that include both large and small shrubs. Plant lists were developed and plant materials purchased in August of 2010. There was much discussion about the plants to include in this site. Specific pest-host interaction concerns were discussed; however the grower was not greatly concerned because his pest pressure is low. This low pest pressure is possibly due to the very high diversity of his cropping system and careful crop rotation plan. Also, this landowner has abundant natural habitat, hedgerows, and general biodiversity on his farm.

In the fall of 2010, four different hedgerows were planted**,** varying in width and length. All areas were planted using containerized stock because the organic farm weed management and site prep limitations made planting wildflowers from seed too risky.

One area was planted in perennial wildflowers from smaller containers (mostly treebands, which are bigger than plugs but smaller than gallons), the rest of the areas were woody hedgerows. The total area planted was approximately 7,765 ft2, with approximately 25 species used. Planting occurred in two stages: two hedgerows were planted on Oct 28 and 29, and the remaining hedgerows were planted on Dec 13 and 14, 2010. All of the planted areas were mulched with straw for weed management and drip irrigation installed in all areas at the time of planting. Monitoring for plant establishment and bloom phenology began in March 2011.

Bee monitoring was conducted from July 2010 through fall 2010 to collect baseline data. Monitoring of project areas resumed in the spring of 2011, and has continued on a monthly basis throughout the 2011 and 2012 season. These monitoring data have been submitted to Xerces. In order to facilitate bee monitoring, additional RCD staff from Santa Cruz attended Xerces' Citizen Science Bee Monitoring Training in June 2011. The data gathered from this monitoring will be very important in evaluating the effectiveness of pollinator hedgerows in increasing bee abundance and diversity in agricultural landscapes.

Plant establishment and bloom phenology monitoring began in the spring of 2011 and has continued consistently throughout the duration of the project. Overall, habitat establishment has been very good. The larger planted areas have established very successfully and are thriving. The two smaller areas had mixed establishment due to a number of factors including foot traffic, weed pressure, and gophers.

The areas that had mixed establishment were partially re-planted in the fall of 2011. Steps were taken to eradicate gophers from the area and reduce foot traffic, and thick straw mulch was spread to control weeds. The RCD secured additional funding to expand the project by planting several new pollinator hedgerows on the farm, and by extending the length of one of the existing hedgerows. The RCD took the lead on these new plantings, but Xerces assisted with site preparation recommendations, plant selection, and planting.

Most of the plants throughout all of the project areas are flourishing. Weed competition continues to be a challenge in portions of the hedgerows, but the RCD has been working closely with the landowner to keep the project sites well-maintained.

Ventura County / Santa Barbara County (Diversified School Farm)
Ventura County was suggested as a potential location for a project site by the NRCS California state office. Xerces staff discussed the project with the local RCD, but due to changes to the Conservation District's budget, they were not able to take part in the project. We were referred to Santa Barbara County, which is adjacent to Ventura County, as an alternative site.

The NRCS in Santa Maria (Santa Barbara County) is working with a grower (the Midland Boarding School) in the region on restoration project funded by the Conservation Stewardship Program (CSP) and thought the grower would be interested in expanding their project to include pollinator habitat. The Midland Boarding School includes a working farm consisting of mixed orchards and row crops. The farm has several existing hedgerows and is surrounded by natural habitat.

In the fall of 2010, both Midland Boarding School and the RCD in Santa Barbara County received detailed information about this project through phone calls and emails and confirmed that they wanted to work with us. Santa Maria NRCS has a CSP pollinator project with the Midland Boarding School farm already underway. The farm agreed to combine this CSP work with our CIG project, adding additional hedgerow and meadow areas to increase the overall area planted and ensure that these two projects were additive. The farm manager agreed to plant 20,000 ft2 for his CSP contract and an additional 7,500 ft2 of habitat for his participation in this CIG project.

Xerces and the local RCD completed a site visit and meetings with the farm manager and his staff during the winter of 2010. Site preparation and planting plans were developed, with the goal of planting the site in the fall of 2011. The habitat design consisted of a large area of wildflowers planted from seed and an adjacent hedgerow of woody plants.

Planning and site preparation continued on schedule throughout the next 6 months. The planting areas were managed consistently for weeds throughout the spring and summer, primarily by monthly shallow (less than 2 inches) disking and hand pulling weeds. Plant lists for the hedgerow were developed, and the plant order was finalized.

The pollinator habitat project was planted in the fall of 2011 and consists of a 600' linear hedgerow and a 3,000 ft2 wildflower area. The hedgerow includes both woody plants and larger perennial forbs and is being irrigated using a drip-system. The forb area was divided into 4 slightly raised beds about 2 feet in width, with 18 inch pathways on either side of the beds. These pathways will be utilized for access to weeding and maintaining the forb beds. Each bed was planted with two linear rows of forb mix using an Earthway seeder. The wildflower species were divided into two mixes based on the size of the seeds to facilitate the calibration of the seeding equipment. The wildflower area will receive minimal irrigation.

The RCD project partner began monitoring the area over the winter of 2011-2. Monitoring has been consistent and thorough. There was excellent establishment of both the forb and hedgerow areas thanks in large part to regular weeding during early establishment and careful maintenance by students at the farm school.

Lockeford Plant Materials Center

Using non-CIG funds, four pollinator hedgerows at the Lockeford PMC were installed in January 2009. We extended these hedgerows to 210 feet in November of 2009, again using non-CIG funds, to allow for comparison with CIG project sites. Using observational data on seed germination, bloom phenology and plant establishment success from other pollinator habitat sites, we worked with the PMC to revise the plant list, seeding rate, irrigation plan, and planting plan. Throughout 2009 and 2010, we continued to collaborate closely with the PMC, by providing technical support and trainings.

In the fall of 2011, Xerces Society staff met with PMC staff to plan additional pollinator plantings at the PMC. Xerces agreed to assist in designing and planting small, low growing pollinator hedgerows in order to create a model hedgerow that can be used in situations where a farmer has limited space and wants to avoiding shading adjacent crops or that could be adopted

for field borders. This plan would have allowed us to field trial smaller pollinator plants or dwarf varieties (naturally occurring selections) of larger pollinator plants. Implementing this plan has been put on hold, however.

Xerces and PMC staff also discussed designing and planting a wildflower meadow area in order to gather more experience and information on successfully establishing wildflowers. Of special interest to the PMC was the use of organic/non-chemical weed abatement and management techniques, including solarization and different mulches.

Along with the Lockeford PMC, Xerces collaborated with the Neal Williams Lab at UC Davis and Hedgerow Farms (a native seed producer) to develop seed mixes and planting plans for these wildflower meadows. Plans included testing a previously developed seed mix, a seed mix that includes plants that have established especially successfully in our CIG trials, and a mix with several new wildflower species thought to be attractive to pollinators but not yet trialed in previous mixes by either Xerces or UCD. A 1.7 acre area at the PMC was delineated and tilled to create a fine seed bed in fall 2011, and the site was planted on November 14 and 15, 2011.

There was excellent germination of wildflowers in the spring of 2012 and throughout the summer on all of the test plots. Weed pressure was moderate and weeds have been controlled through a combination of targeted herbicide use ('spot spraying'), mechanical (hand) weeding, and mowing. Plant establishment and bloom phenology monitoring was conducted by PMC staff in the wildflower areas during 2012.

California Outreach[1]

The local media have shown an interest in our project in San Diego, and two articles about it appeared in local papers in November 2010. This pollinator habitat planting was also included as a stop in a farm tour given by the landowner, George McManigle, in February 2011. Xerces supplied information and handouts for the tour.

On May 26, 2011, Xerces' California project coordinator gave a talk and tour of our rangeland pollinator site in Glenn County.

Other Project Outreach

In July, 2012, Xerces staff gave a poster presentation about this project, as well as a workshop about pollinator habitat establishment based on this project, at the annual meeting of the Soil and Water Conservation Society in Fort Worth, Texas. At this CIG Showcase, Xerces unveiled draft copies of our pollinator habitat job sheets for the six regions of the U.S. where we are working. As part of a special symposium on the CIG program, Xerces' Pollinator Program Director also gave a presentation about the three CIG grants we are currently managing, and the value of the CIG program for fostering innovations in conservation.

On September 29, 2012, Xerces Pollinator Program Director gave a presentation about this project and the guidelines we are developing to a meeting of the Canadian Pollinator Initiative.

[1] Note that several outreach events relevant to this grant were carried out and funded under a California State CIG grant (Agreement 68-9104-9-115). This state CIG grant targets restoration in the San Joaquin Valley but outreach throughout the state.

Approximately 40 scientists from across North America who are studying role and habitat needs of pollinators in agriculture attended this presentation. This talk is part of Xerces Society efforts to share project results with broader audiences who can help put our results into practice.

CONCLUSIONS AND RECOMMENDATIONS

We successfully drafted 14 sets of guidelines for wildflower and hedgerow creation for California, Western Oregon and Washington, the Upper Midwest, New England, Pennsylvania, and Florida. These are tools that are ready for landowners to use and now only require fine-tuning and adopting by state office NRCS staff. The adoption process is nearly complete for California, Oregon, and Pennsylvania. We continue to work with Florida, New England states, and Upper Midwest states to help them fine-tune these guidelines and incorporate them into their electronic field office technical guides.

By conducting pollinator habitat field trials in several regions of the U.S., utilizing several different approaches to weed abatement and site preparation, several trends emerged that are reflected in the Conservation Cover and Hedgerow specifications and implementation requirement forms we developed for NRCS state offices.

The restoration guidance we developed for conservation planners targets the most straightforward and consistent methods for site preparation, weed abatement, and planting. We looked for key points in the restoration process where mistakes can be made and then recommended techniques that limit chances of failure.

For example, one can be successful seeding perennial wildflowers in the spring, but to ensure that perennial seeds receive adequate winter stratification the first year and maximize germination the first growing season, we recommend dormant season planting in all regions.

Similarly, weed competition during the first year of establishment is going to be the biggest challenge to wildflower establishment. Therefore, we recommend a very aggressive approach to weed abatement prior to planting. This includes at least a full growing season of weed control starting with spraying of cool season weeds as soon as they germinate in the winter or spring prior to planting. We also recommend that – unless absolutely necessary – absolutely no tillage be conducted at a restoration site. This reduces the chance of erosion, but more importantly we emphasize that it is critical to remove weed seed from the top layer of soil. Any tillage brings new weed seed to surface and eliminates any weed abatement conducted prior to tillage.

For planting, we also emphasize the importance of using seeding techniques that minimize opportunities for planting seed incorrectly. This means focusing on hand broadcasting and rolling in seed for sites less than 2 acres. This technique is simple, and if proper site preparation has occurred, eliminates the risks associated with seed drills that may plant seed too deeply or drop seeders that need to be calibrated and set up specifically for planting native seed that varies significantly in size.

Finally, we emphasize that it is critical to come back to sites the year after planting to remove annual weeds, either by mowing at 8 inches high or spot treatments. The investment in time and

resources to aggressive site preparation and then this follow up annual weed control has resulted in successful plantings in all regions where we worked.

This overall approach to establishing wildflowers and shrubs has simplified our message to NRCS conservation planners, created a conservative and careful framework for establishing permanent meadows, and resulted in tools for the NRCS that help ensure successful plantings for most regions of the U.S. Several state NRCS offices have let us know how much they value the tools we developed, and our experience on this project has informed similar guidelines (job sheets, specifications, or implementation requirement forms) for Delaware, Maryland, New Jersey, Kentucky, and Rhode Island. We anticipate helping several other states with similar guidelines and training over the coming years.