PROJECT TITLE: Bee Pollinator Habitat Enhancement

Project Manager: Marla Spivak
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Funding Source: Environment and Natural Resources Trust Fund
Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 04h

Appropriation amount: $200,000.

Our goal was to develop an innovative way of helping bee pollinators by enhancing turf areas with native flowering plants. Planting "bee lawns" could help reduce intensive inputs (pesticides and fertilizers) and provide low-growing floral areas, which would beautify Minnesota and provide a creative model for a simple yet effective way to help pollinators and protect our natural resources. First, we identified turf grasses that are well suited to incorporating flowering plants. We found that hard fescue, *Festuca brevipila*, like other fine leafed fescues, demonstrates drought tolerance, slow vertical growth rate, and excellent winter hardiness making it suitable for a lower-input lawn species. Next, we found that native floral species, *Prunella vulgaris* spp. *lanceolata* and *Astragalus crassicarpus* established well in hard fescue, with *Prunella* establishing better in loamy soil and *Astragalus* in sandy soil. We also found that *Symphyotrichum lateriflorum* (native calico aster) would bloom at a low height under light mowing pressure, making it a third native species for incorporation into turf. These experiments were important first steps in identifying native plants to diversify lawns that are both attractive to pollinators and can withstand mowing pressure. To assist homeowners in establishing flowers in their own existing home lawns, we subjected turf areas in two locations to scalping and/ or aeration and then seeded them with native flowers. The flowers established at higher rates at the location that used minimal turfgrass management (infrequent mowing and no fertilizer use) compared to the more intensively managed site. This latter finding indicates that flowering lawns will do best with lower inputs, which will contribute to more sustainable landscapes that are beneficial to pollinators. Ian Lane, graduate student that conducted this work, defended his Master's degree in May 2016.

Project Results Use and Dissemination
We have reached a broad audience with research-based information about bee lawns. Professional audiences have been reached through articles in trade journals. Hobbyist audiences have been reached through presentations at local, regional, and national meetings. Scientific audiences have been engaged through departmental seminars and national scientific meetings. Ian Lane, graduate student, will produce at least three peer-reviewed publications from this project. Most importantly, the general public has been reached in a number ways: we hosted five field days, 3,000 copies of a new brochure on Bee Lawns were distributed, and a new page on the Bee Lab website at the University of Minnesota was developed with information on planting and maintenance of Bee Lawns: www.beelab.umn.edu/bees/beelawn A pdf copy of the brochure and evaluations from attendees of the 2016 field day are included as an Addendum to this report.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2013 Work Plan Final Report

Date of Status Update Report: August 2016

Date of Next Status Update Report: Final Report

Date of Work Plan Approval: June 11, 2013

Project Completion Date: June 30, 2016

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Location: Ramsey Co, Carver Co, and Statewide

Total ENRTF Project Budget:	
ENRTF Appropriation:	**$200,000**
Amount Spent:	**$190,108**
Balance:	**$9,892**

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 04h

Appropriation Language:
$200,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to assess the potential to supplement traditional turf grass by providing critical floral plant resources to enhance bee pollinator habitat. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Bee Lawns: A Unique Way to Help Pollinators

II. PROJECT STATEMENT:

The goal of our proposed research is to develop an innovative way of helping bee pollinators while enhancing the environment and protecting natural resources. We are seeking options for turf areas that are not used for human recreation but are still maintained by mowing and intensive inputs of water, fertilizers and pesticides. Planting bee lawns would reduce these inputs and provide low-growing floral areas, which would beautify Minnesota and provide a creative model for a simple yet effective way to help pollinators and protect our natural resources.

Bee pollinators (honey bees, *Apis mellifera*, and over 400 species of native bees) are in trouble. Bee health is failing across MN and the nation due to a scarcity of bee-friendly flowers leading to nutritional deficiencies, chronic exposure to pesticides, and debilitating diseases, and parasites (Spivak et al., 2011). Bees play a key role in American agriculture through pollination; the U.S. grows more than one hundred crops that either need or benefit from pollinators with an economic value estimated at $20 billion in 2000. The Upper Midwest states, including MN, ND and SD, are the top honey producing states in the nation. Commercial beekeepers transport their colonies to our region for the summer months for honey production after fulfilling pollination contracts in other parts of the nation. People are taking action to rectify the decline of pollinators by becoming beekeepers, reducing pesticide exposure to bees, and planting flowers to support the nutritional needs of all bees. Seed mixtures and designs for bee-friendly flower gardens are becoming prevalent across the nation. The National Resource Conservation Service and Farm Services Agency have implemented incentive programs for pollinator landscape enhancement through the 2008 Farm Bill, which are becoming increasingly popular. We propose to research the potential multiple benefits of a unique type of landscape - bee lawns - to support pollinators and reduce intensive inputs.

Turfgrass makes up a significant part of the urban landscape but provides no nutritional resources for pollinators. Some turf areas, such as those in out-of-play roughs on golf courses, cemeteries, large commercial properties and boulevards, are rarely used by people and primarily serve an aesthetic purpose. There is recent interest in the use of lower-input grasses in these turf areas as a way to reduce inputs of water, fertilizer, and pesticides (Watkins et al., 2011). Many of these areas may also be useful as bee lawns; i.e., a low-input turf area that also contains low-growing flowering plants that can be utilized by important bee pollinators. These low-growing flowering plants would need to have characteristics that contribute positively to a sustainable landscape that maintains turf function (slow vertical growth rate, contribution of nitrogen due to nitrogen fixation, ability to vegetatively reproduce in a perennial system, positive aesthetics in urban settings). Bee lawns would provide a natural buffer to water resources in areas where low-growing, more manicured looking lawns are preferred. Although this idea is novel, the use of non-turfgrass species in lawns is not. In the mid-20th century and before, white clover seed was often included in lawn seed mixtures in order to decrease the need for nitrogen fertilization. Before bee lawns can be recommended, we must research the correct grass-flower combination that would fulfill the requirements of a bee lawn (produces flowers useful to pollinators and tolerates mowing while maintaining the function and aesthetics of the turf).

We propose two activities: 1) Bee lawn evaluation trials, and 2) Public demonstration plots. Research will be conducted in 25 plots containing turfgrass-flowering plant combinations split between the St Paul campus and the University of Minnesota Landscape Arboretum. These research plots also will serve as demonstration plots for public viewing. In this way, we combine research and outreach in a transparent and effective way. People interested in growing a bee lawn can observe the progression of flowering through two years and choose among different flowering densities and turf options to suit their landscape needs and uses.

III. PROJECT STATUS UPDATES:

Project Status as of: January 2014

Trials were initiated in late summer 2013 to determine the ideal grass species to use with flowering plants in Minnesota, and to determine which flowering plants would be appropriate in a bee lawn. In the first trial, Kura clover (*Trifolium ambiguum)* -- a model flowering plant – was seeded at different rates into four different turf grass species: Kentucky bluegrass, hard fescue, tall fescue, and perennial ryegrass. The number of clover plants that establish and the percentage of ground they cover will be monitored next summer under different mowing regimes. In the second trial five different species of flowering native plants, known to be highly attractive to honey bees, were planted to determine if they bloom under different levels of mowing in 2014. These plants

include *Monarda punctata* (dotted bee-balm), *Dalea purpurea* (purple prairie clover), *Astragalus Canadensis* (Canadian milkvetch), *Coreopsis lanceolata* (Lance leaf coreopsis), and *Mentha arvensis* (Field Mint).

Project Status as of: September 2014

Activity 1. *Experiment 1: Ideal grass species for bee lawn. Festuca trachyphylla* (hard fescue) and *Poa pratensis* (Kentucky bluegrass) had significantly higher establishment of *Trifolium ambiguum* (Kura clover) than *Lolium perenne* (perennial ryegrass) and *Festuca arundinacea* (tall fescue) throughout the growing season. *Experiment 2: Mowing height and bloom in hard fescue*. Initial results showed that *Trifolium repens* (Dutch white clover) and a native flower *Prunella vulgaris* (self-heal) had the best germination and bloom when mixed with hard fescue grass. *Thymus serpyllum* (creeping thyme) and a native forb *Astragulus crassicarpus* germinated and established but did not flower. No difference was noted between mowing heights on the number of blooms or plant establishment. Other native flowers will be tested in 2015. *Experiment 3: Effect of mowing on native forbs*. Native flowering plants (planted alone, not in fescue), *Monarda punctate* (dotted beebalm), *Dalea purpurea* (purple prairie clover), *Coreopsis lanceolata* (lance-leaf coreopsis), and *Astragalus canadensis* (Canada milkvetch) were subjected to differing mowing heights but no plant achieved bloom under our experiment parameters. Trials will continue in 2015. *Experiment 4: Forb seeding into established lawns*. We seeded *T. repens*, *P. vulgaris*, and *T. serpyllum* at three different rates into a mature Kentucky bluegrass stand that had been 1) aerated, 2) scalped, 3) aerated+scalped, or 4) not treated. Scalping positively affected *T. repens* establishment, and scalping+aeration at higher seeding rates positively affect *P. vulgaris* establishment.

Activity 2. This project has been showcased at 1) the Minnesota Turf and Grounds Field Day at the University of Minnesota, 2) the Urban Forestry Outreach and Research Field Day, 3) a virtual field day (available at turf.umn.edu), 4) two public talks and a poster at the American Beekeeping Federation.

Project Status as of: March 2015

Activity 1. *Experiment 1: Ideal grass species for bee lawn.* Next summer will be our final year of data collection, after which we will fully summarize the results and publish them. *Experiment 2: Mowing height and bloom in hard fescue*. Further data analysis revealed that *Thymus serpyllum* established in higher numbers at the Becker research farm, suggesting sandy soil may favor this particular forb. Currently we plan to continue data collection this summer and add timed observations of the flowering plants to determine bee visitation. *Experiment 3: Effect of mowing on native forbs*. Mowing protocol will be modified slightly to mow plots only if leafy tissue passes a height threshold (rather than when flowering shoots pass a threshold). Native plant *Symphyotrichum lateriflorum* (Calico aster) and *Menthe arvensis* (field mint) have been added to this study while *Dalea purpurea* (purple prairie clover) was removed. *Experiment 4: Forb seeding into established lawns.* We plan on replicating this study at Victory Links golf course and the St. Paul campus to better study the effects of mechanical disruption on forb establishment.

Activity 2. Ian Lane has presented his preliminary findings at the national Entomological Society of America meeting, a public seminar through the department of Entomology, and to students taking a Turfgrass Management course. In public venues, Ian lane has presented at "Super Tuesday" (the event preceding the Green Expo at the Minneapolis Convention Center). Future public outreach events include presentations at the MN Landscape Arboretum. M. Spivak has presented information and status updates on the Bee Lawn project at many public talks and venues and has received lots of positive feedback and interest in this project. Many people are waiting for the results of this research, and are excited about planting a Bee Lawn on their property.

Project Status as of: September 2015

Activity 1. *Experiment 1: Ideal grass species for bee lawn.* The final round of data has been collected on all trials for this experiment. Data analysis is forthcoming, and we anticipate informative results. *Experiment 2: Mowing height and bloom in hard fescue*. Native forb *Astragalus crassicarpus* was found growing and flowering in research plots at Becker. In addition *Thymus serpyllum* was found established and flowering in high densities at the same site. Further data analysis will reveal if mowing treatments played a significant role in bloom density. Results highlight the importance of site-specific conditions in flower establishment. In St. Paul, we continued to see high numbers of blooms of *Trifolium repens* and *Prunella vulgaris*, but no blooming of *Thymus serpyllum* despite that it has established effectively. *Experiment 3: Effect of mowing on native forbs.* Native plant *Symphyotrichum lateriflorum* (calico aster) exhibited high numbers of blooms under all mowing treatments, and is a good candidate for further incorporation into lawn settings. While lanceleaf coreopsis showed promise as well, the plants we tested (*Menthe arvensis*, *Monarda punctata*, and *Astragalus canadensis)*, failed to bloom under all

mowing conditions. *Experiment 4: Forb seeding into established lawns*. This study was conducted at research sites in Blaine and Woodbury beginning in May of this year. Data has been collected and preliminary review of the data suggests management specific effects may be interacting with treatment effects. Further review is needed but initial results are promising.

Activity 2. Ian Lane has presented preliminary findings at the American Public Garden Association in the form of a poster, at multiple events through UMN Extension at the Landscape Arboretum, and at a field day specifically for St. Paul Public Parks Employees. Future planned talks include presenting a research talk at the Entomological Society of America meetings and a research poster at the Crop Science Society of America meetings. In addition Ian will address the Minneapolis Parks board of directors about bee lawn research results and possible future implementation. Ian was recently awarded the "Masters Achievement Award" through the Entomological Society of America's plant-insect ecosystems section, which will also increase this projects exposure.

An intern was hired at the arboretum to help with the establishment of public demonstration Bee Lawn at the Minnesota Landscape Arboretum and to assist in the design of educational material and web resources. Public Bee Lawn Open House events were held at the Arboretum and the demonstration Bee Lawn is seen by hundreds of people each week along the main drive in the Arboretum. The Lake Minnetonka Garden Club toured the plots and were given the ***Help Pollinators by Planting a Bee-Friendly Lawn*** information sheet. The Arboretum Tour Guides and Tram Drivers have been given information about the Bee Lawn and are sharing this information with Arboretum visitors.

Amendment Request (10/26/2015)

We are requesting an amendment that will shift $36,859 in funding from Activity 2 to Activity 1. The research projects associated with Activity 1 have yielded very interesting results. In order to collect as much data as possible on these trials, we are requesting that activities associated with Activity 1 continue until the very end of the grant period. In particular, the graduate student will continue to collect data on Experiment 2 and Experiment 4. In both of these cases, an additional spring of data collection will help to confirm our initial observations and lead to a higher quality final research report. In the case of Experiment 2, we will repeat the experiment beginning in spring of 2016. While some of the results from this repeated experiment will be known before the end of the grant period, we will use other funding to ensure that a full growing season of data is collected on this experiments. This will lead to more robust data that can be reported in a peer-reviewed scientific journal. There is also a significant amount of data that must be entered and analyzed during the winter and we will use funding from Activity 1 to support personnel to help in this task. Finally, we have need for additional supplies that will be useful for insect collections on research plots during the spring of 2016.

This request is possible because we have been able to have a significant outreach effort at lower costs than were anticipated early in the grant period. As the projects comes to a close, we will continue outreach efforts in four ways: (1) we will develop a webpage that will be housed on the popular Minnesota Landscape Arboretum website and also develop web content for the BeeLab.umn.edu and turf.umn.edu websites; (2) we will produce a brochure that is based on our work and make it freely available to all Arboretum visitors and visitors to the St. Paul campus display gardens; (3) we will hire an intern to continue maintaining demonstration plots and helping with the development of online content at the Arboretum; and (4) we will plan and host a public field day on the St. Paul campus primarily focused on bee lawns and other strategies for helping pollinators in urban landscapes. This field day will be held in June 2016, likely on a Saturday morning so that it does not interfere with typical workweek. Presenters will include graduate students, faculty, research scientists, and extension educators working on pollinator and low-input landscape issues. Funding will be used for costs associated with the field day including parking, food, advertising, transportation around campus, etc. Our goal is to have at least 200 people at this event. Collaborators in Extension will help organize and coordinate this event due to their extensive experience in these types of field days. To this point, we have been able to reach a significant audience at field days, public events, research seminars, and other events, all of which did not have significant costs beyond personnel time.

Amendment Approved: Approved by LCCMR 11-16-2015

Project Status as of: March 2016

Activity 1. *Experiment 1: Ideal grass species for bee lawn.* Final analysis for this experiment has been conducted. Kura clover (used only as a model flowering species) established well in Kentucky bluegrass in both trials, and in hard fescue in the first trial, but not in tall fescue and perennial ryegrass in either trial. *Experiment 2: Mowing height and bloom in hard fescue*. All data for this experiment has been analyzed. Control species, *Trifolium repens,* bloomed and seemed unaffected by mowing in all locations, though it did seem to establish better in sandy soils. Native *Astragalus crassicarpus* established only in our sandy site and seemed unaffected by mowing. It bloomed, but not in high amounts. Native, *Prunella vulgaris* spp. *lanceolata* established at both locations, but only bloomed at our loamy site, and its blooming was adversely affected by lower mowing heights. *Thymus serpyllum* established at both sites, but only bloomed at the sandy location and at higher mowing heights. All other forb species did not establish. Experiment *3: Effect of mowing on native forbs*. No further updates, this experiment has concluded. *Experiment 4: Forb seeding into established lawns*. Results from first year of study suggest that scalping lawns before seeding of *Trifolium repens* is beneficial of establishment. Results for *Prunella vulgaris* spp. *lanceolata* suggest that scalping is only helpful in establishment if the lawn is under intense management in the form of inputs (fertilizer and irrigation) and mowing. Both scalping and aeration of intensely managed lawns before seeding of *Thymus serpyllum* affected establishment.

Activity 2. We have hired a student intern to develop content for a webpage on Bee Lawns. This online information will be for the general public as well as grounds maintenance and parks personnel who want to know more about bee lawns and how to incorporate them into their landscapes. The Bee Lawn website is expected to be live by the end of April 2016 and will be added to through the end of this project.

The student intern will also be developing content for the Bee Lawn brochure which will be distributed at the Minnesota Landscape Arboretum and the St Paul Display and Trial Garden. The brochure will inform the public about the bee lawn project, how they can make changes in their home landscape and where to see the bee lawn at the Arboretum. The brochure is planned to be completed and at the printer by May 15, 2016.

We are finalizing the date for the public Field Day on the St Paul campus which will be held in June in collaboration with Extension colleagues.

Ian Lane presented a research talk at the Entomological Society of America meeting, and a research poster at the Crop Science Society of America meeting. Ian also addressed the Minneapolis Parks board of directors about bee lawn research results and possible future collaboration. M. Spivak presented numerous research and outreach talks throughout the year that included information on this project, and consistently received positive feedback about it and requests for how-to information.

Overall Project Outcome and Results

Our goal was to develop an innovative way of helping bee pollinators by enhancing turf areas with native flowering plants. Planting “bee lawns” could help reduce intensive inputs (pesticides and fertilizers) and provide low-growing floral areas, which would beautify Minnesota and provide a creative model for a simple yet effective way to help pollinators and protect our natural resources. First, we identified turf grasses that are well suited to incorporating flowering plants. We found that hard fescue, *Festuca brevipila,* like other fine leafed fescues, demonstrates drought tolerance, slow vertical growth rate, and excellent winter hardiness making it suitable for a lower-input lawn species. Next, we found that native floral species, *Prunella vulgaris* spp. *lanceolata* and *Astragalus crassicarpus* established well in hard fescue, with *Prunella* establishing better in loamy soil and *Astragalus* in sandy soil. We also found that *Symphyotrichum lateriflorum* (native calico aster) would bloom at a low height under light mowing pressure, making it a third native species for incorporation into turf. These experiments were important first steps in identifying native plants to diversify lawns that are both attractive to pollinators and can withstand mowing pressure. To assist homeowners in establishing flowers in their own existing home lawns, we subjected turf areas in two locations to scalping and/ or aeration and then seeded them with native flowers. The flowers established at higher rates at the location that used minimal turfgrass management (infrequent mowing and no fertilizer use) compared to the more intensively managed site. This latter finding indicates that flowering lawns will do best with lower inputs, which will contribute to more sustainable landscapes that are beneficial to pollinators. Ian Lane, graduate student that conducted this work, defended his Master’s degree in May 2016.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: *Bee Lawn Evaluation Trials*

Description: This activity outlines our proposed research. We will evaluate a series of grasses in mixtures with low-growing flowering plants that can sustain growth within the turf, tolerate mowing and continue flowering after occasional mowing. We will evaluate low-input grasses (examples of species that could be tested include Chewings fescues, hard fescue, sheep fescue, tall fescue, and prairie junegrass - a native grass currently being improved for turf use at the University of Minnesota). The flowering plants we will evaluate include native low-growing forbs such as lanceleaf coreopsis, field mint (*Mentha arvensis*), and blue-eyed grass (*Sisyrinchium angustifolium.* Our consultation with Ron Bowen at Prairie Restoration, Princeton, MN, and Pollinator Specialists at Xerces Conservation Society indicate that it may be difficult to identify a variety of native species that can tolerate mowing and continue to bloom. Therefore we will also evaluate a series of low-growing, flowering non-native legumes (examples include alfalfa, Kura clover, white clover) that we know can withstand mowing. In all cases, we will ensure our floral selection does not contain species known to be highly invasive. The turf-floral evaluation trial will be established in late summer 2013 at both the St. Paul campus of the Univ. MN and also at the MN Landscape Arboretum. A total of at least 25 turfgrass-flowering plant combinations will be included. The species will be selected after thorough review of the literature and extensive consultation with horticulturalists with flowering plant expertise.

Plots will be planted in four replications in a randomized complete block design. Data will be collected through June 2015 on overall turf quality, floral abundance, freedom from turfgrass diseases, the ratio of grass to floral mixture over the years, and bee visitation rates (honey bee and native bees),. For most qualitative measurements (turf quality, disease incidence, color, etc.) a typical 1-9 visual scale will be used. In cases where a quantitative measure is more appropriate, we will use digital image analysis (drought stress, plot density, etc.) or the intersect grid method where a grid is overlaid onto the plot and data is collected at each grid intersect (this method is commonly used by turfgrass researchers and will be used for floral abundance and species composition measurements). Data will be analyzed to determine the top-performing mixtures. For bee visitation, native and honey bee visitation on the bee lawn plots will be monitored using standardized methods developed by Dr. Sam Droege of the USGS[1] and routinely used in the Spivak lab. We will sweep-net bees, using insect nets, along transects through each plot every 2 weeks through the growing season (April – September)**.** In addition, pan (cup) traps will be placed along side of the plots for 24 hours every 2 weeks. The traps consist of colored cups containing water mixed with a small amount of dish soap. The bees are attracted to the colored cups and fall into the water because the soap decreases the surface tension. These two measures provide unbiased estimates of bee species diversity and abundance. This measure is necessary to document the benefit of the habitat to bee pollinators, and to inform people about the number of bees they can expect to attract to different floral mixtures within the turf.

This research will comprise the Master's thesis for a new graduate student co-advised by M. Spivak and E. Watkins. Technician (A. Hollman) from the Turf lab will assist with plantings and maintenance of the plots. We intend to complete research in the summer of 2015 but will need time during the academic year 2015-16 to complete analyses and write-up.

Summary Budget Information for Activity 1: *Bee Lawn Evaluation Trials*

ENRTF Budget: $174,034
Amount Spent: $174,034
Balance: $ 0

Activity Completion Date: June 30, 2016

Outcome	Completion Date	Budget
1. Bee lawn plots planted, and top-performing bee lawn turf-floral mixtures will be identified, based on criteria listed above	June 30, 2016	$174,034

Project Status as of: January 2014

[1] www.pollinators.nbii.gov/documents/Handy%20Bee%20Manual.pdf)

Plant selection is an important and complex aspect of the project. The flowering plants will need to follow strict criteria and will need to: 1) be a proven resource for nectar and/or pollen; 2) produce enough blooms under management to attract foragers; 3) have the ability to compete effectively with weeds and turf grass; and 4) be socially acceptable to owners.

Two preliminary projects that will help inform the larger trials were planted this fall of 2013. The goal of the first trial is to determine which grass species and flower seeding-rates will result in an acceptable plant species balance, with Kura clover (*Trifolium ambiguum)* serving as a model flowering plant. Kura clover is ideal as a model forb as it is slow to establish (like many native plants) but is an effective competitor once established. This preliminary trial was set up in a randomized block design containing four different turf grass species: Kentucky bluegrass, hard fescue, tall fescue, and perennial ryegrass. These grasses were mixed with Kura clover at various seeding rates. In these plots I have been monitoring the number of clover plants that establish, as well as the percentage of ground they cover. As the clover matures and begins to flower, I am adjusting the mowing strategies to achieve a balance of flowers and a desired aesthetic by monitoring the number of flowers that are produced between mowing sessions with varying amounts of time between each session. With this data I will determine the ideal grass species to use with flowering plants in Minnesota, as well as a standard seeding rate.

The second preliminary trial also uses a randomized block design in which five different species of flowering native plants known to be highly attractive to honey bees. These native plants are not normally seen in highly managed lawn areas, but based on the recommendations of researchers and horticulturalist we are testing to see if they might be able to bloom while under mowing pressure. These plants include *Monarda punctata* (dotted bee-balm), *Dalea purpurea* (purple prairie clover), *Astragalus Canadensis* (Canadian milkvetch), *Coreopsis lanceolata* (Lance leaf coreopsis), and *Mentha arvensis* (Field Mint). I have been subjecting these stands to differing levels of mowing, and monitoring them for changes in growth habit and flowering.

Research Goals 2014. Based on preliminary data collected from the two summer trials, we have selected the turf grass *Festuca trachyphylla* (hard fescue) and a common seeding rate to begin a broader study of flowering plants usable in a lawn environment. For these trials we have dormant seeded fine fescue over a large area, and then seeded 3' by 3' plots within this area to create single forb and grass combination plots for evaluation. These plants will include the nonnative species white clover (*Trifolium repens*), and creeping thyme (*Thymus praecox)* and the native plants self-heal (*Prunella vulgaris spp. lanceolata),* purple locoweed (*Oxytropis lambertii),* spring beauty (*Claytonia virginica),* cutleaf daisy (*Erigeron compositus*), pasque flower (*Anemone patens*), and ground plum (*Astragalus crassicarpus)*. These plants were selected based on their low growth habit, quality of resource for honey bees, and acceptability to homeowners. Our goal will be to assess if the chosen plants can establish and bloom under a mowing heights of 3.5", and 2.5". Mowing frequency will be determined using the 2/3 rule, in which one never prunes more than 1/3 of the plant. These mowing heights will generate a taller and less frequently mowed treatment, and a shorter more frequently mowed treatment. These plots will be monitored for the population dynamics between the grass and inter-planted flower. The parameters measured will include: abundance, ground cover, and floral area. As flowering plants establish, we will also begin surveying plots that are in bloom for bee visitation based on the number of visits per unit time.

These forbs will also be planted in a separate random block experiment with no grass or mowing pressure. The goal of these plots is to examine how attractive selected plants are to bees without any competitive or management pressures. These plots will be monitored for bee visitation during their bloom periods to establish the attractiveness of selected forbs without the confounding factors of competition and management. This will allow us to know the base-line value these plants have to honey bees, as well as give us a basis of comparison as to how these factors affect the flowers attractiveness to bees

With data taken in the summer of 2014, we can begin to select successful plants for more diverse planting trials in the summer of 2015. This mix will contain the native and nonnative plants able to withstand mowing pressures, competition, and still produce blooms and receive bee visitation

Project Status as of: September 2014

Experiment 1: Ideal grass species for bee lawn. Summer 2014 marked the first year of full season data collection for the Kura clover/grass species trial. Results from this trial clearly show that *Festuca trachyphylla* (hard fescue) and *Poa pratensis* (Kentucky bluegrass) had significantly higher establishment of *Trifolium ambiguum* (Kura clover) than *Lolium perenne* (perennial ryegrass) and *Festuca arundinacea* (tall fescue) throughout the growing season. Establishment was measured by the number of trifoliate leaves, percentage of ground covered, and number of blooms. These results have implication for choosing grass species with which to

design a lawn seed mix with flowering plants. We will continue to collect data on this trial in summer of 2015, as well as replicate this trial to see if our results are robust.

Experiment 2: Mowing height and bloom in hard fescue. In addition we collected first year data on our mowing height trial in which we mixed single flowering forbs with hard fescue. Initial results show that high germination was achieved by *Trifolium repens* (Dutch white clover) and a native flower *Prunella vulgaris* (self-heal). Both species bloomed in their establishment year. In addition *Thymus serpyllum* (creeping thyme) saw germination and establishment of plants but no flowering, as well as small number of the native forb *Astragulus crassicarpus* (ground plum). In the first year we detected no difference between mowing heights on the number of blooms or plant establishment. We will continue to measure bloom and plant establishment of established species, as well as for delayed germination of other planted native species *Aenemone patens* (pasque flower) *Erigeron compositus* (cutleaf daisy), *Claytonia virginica* (spring beauty) and *Oxytropis lambertii* (purple locoweed) in these trials in the summer of 2015 to see if mowing height will effect plants after they become more established.

Experiment 3. Effect of mowing on native forbs. Summer 2014 also was the first year where we subjected four native flowering plants: *Monarda punctate* (dotted beebalm), *Dalea purpurea* (purple prairie clover), *Coreopsis lanceolata* (lance-leaf coreopsis), and *Astragalus canadensis* (Canada milkvetch) to differing mowing heights to test if they might be suitable in a more grass lawn mix. No plant achieved bloom under our experiment parameters using the 1/3 rule, though all survived the mowing treatments except *D. purpurea*. *D. purpurea* was replaced with *Symphyotrichum lateriflorum* (calico Aster) and *Menthe arvensis* (field mint) was added to be evaluated in summer 2015.

Experiment 4. Forb seeding into established lawns. Beginning in late spring of 2014 we also initiated a study in which we sought to evaluate if different management techniques would affect the establishment of forbs planted directly into established lawns. In this study we selected a mature Kentucky bluegrass stand in which we evaluated the effect of aeration, scalping, aeration+scalping, and no treatment, on three different seeding rates for each of *T. repens, P. vulgaris,* and *T. serpyllum*. Our first year results indicate that scalping positively affects *T. repens* establishment, and that scalping+aeration and higher seeding rates positively affect *P. vulgaris* establishment. In this trial we did not see any effect of these treatements on *T. serpyllum*. These results have real world value as management guidelines for establishing clover and self-heal in home lawns. In the summer of 2015 we will seek to replicate these results on campus and at the University of Minnesota Landscape Arboretum.

Project Status as of: March 2015

Experiment 1: Ideal grass species for bee lawn. Since September 2014 no further data collection has been possible due to winter. Management and data collection will continue for this experiment in the summer of 2016.

Experiment 2: Mowing height and bloom in hard fescue. Since September 2014 no further data collection has been possible. In summer 2015, we plan to add timed observations of bees foraging on the research plots to determine bee response to flowering plants in lawns. This will be in addition to the plant counts and cover data being taken already.

Experiment 3. Effect of mowing on native forbs. Since September 2014 no further data collection has been possible. Mowing protocol will be modified slightly so that only leafy biomass that passes our mowing threshold will trigger a mowing event, rather than when the flowering shoots pass the threshold. We think this modification will allow for more floral blooms.

Experiment 4. Forb seeding into established lawns. Current plans to replicate this trial have shifted from the MN Landscape Arboretum to an off campus site located in a bluegrass nursery of Victory Links golf course in Blaine, MN. In September we will plant a patch of bluegrass intended for this study on campus.

Project Status as of: September 2015

Experiment 1: Ideal grass species for bee lawn. Data collection for this experiment has been completed. Results will be available pending data analysis.

Experiment 2: Mowing height and bloom in hard fescue. Data collection has been completed on these research plots. Preliminary observations suggest strong effects of site conditions on bloom. *Trifolium repens* (Dutch white clover) establishes well in most conditions, and a native flower *Prunella vulgaris* (self-heal) establishes particularly well in moist fertile sites. *Thymus serpyllum* (creeping thyme) and native forb *Astragulus crassicarpus* (ground plum) establish better in sandy soils and low fertility sites. Bloom observations were done for thyme, self-heal, and clover, and species visitation data will be available upon identification and databasing of specimens.

Experiment 3. Effects of mowing on native forbs. Of the five plants investigated —*Menthe arvensis, Coreopsis lanceolate, Monarda punctate, Astragalus canadensis,* and *Symphyotrichum lateriflorum*— *Symphyotrichum lateriflorum* and *Coreopsis lanceolate* hold the most promise for future research trials. The next step will be to establish these plants in mowed turfgrasses.

Experiment 4. Forb seeding into established lawns. This experiment was established at Victory Links golf course in Blaine as well as at Stone Mill Park in Woodbury. These plots were large with high amounts of replication in order to get best results. Initial inspection of the data suggests that scalping and aeration treatments have the strongest effect in the highly managed lawns of Victory Links Golf Course, while Woodbury had weaker and potentially insignificant establishments between treatments. Further analysis is needed but initial results suggest that additional action for establishing forbs is only needed in highly managed lawns. This will be valuable information for homeowners wanting to add pollinator foraging resources into existing lawns.

Project Status as of: March 2016

Experiment 1: Ideal grass species for bee lawn. Data collection and analysis for this experiment has been completed. Results point to slow-growing grasses having the most Kura clover establishment, including Kentucky bluegrass and hard fescue.

Experiment 2: Mowing height and bloom in hard fescue. Data collection and analysis has been completed on these research plots. Results suggest mowing height does have an effect on *Thymus serpyllum* (creeping thyme) and *Prunella vulgaris* spp. *lanceolata* (native variety of lance leaf self heal) bloom, but not on vegetation. *Trifolium repens* (Dutch white clover) establishes well in most conditions and mowing does not seem to affect bloom or vegetation. Native *Prunella vulgaris* (self-heal) establishes particularly well in moist fertile sites. *Thymus serpyllum* (creeping thyme) and native forb *Astragulus crassicarpus* (ground plum) establish better in sandy soils and low fertility sites. Visitation data for *Prunella vulgaris* spp. *lanceolata* found no usage by honey bees (*Apis meliffera*), but high usage by bumble bees and native solitary bees.

Experiment 3. This study has concluded, and results have not changes since last update.

Experiment 4. Analysis of data suggests that scalping assists with the establishment of white clover regardless of site type. This benefit extended to self-heal, but only at the highly managed site. Scalping and aeration together was the only treatment that improved creeping thyme establishment, and only at the highly managed site. Results for self-heal and creeping thyme at the low management site were less clear. Another year of study is required to draw further conclusions.

Final Report Summary

We conducted four experiments under Activity 1. The goal of Experiment 1 was to identify turf grasses that are well suited to incorporating flowering plants. This study tested the hypothesis that slower growing turf grasses and higher forb seeding rates will favor the establishment of slower growing and less competitive forbs. To do this we used a flowering forb, Kura clover (*Trifolium ambiguum* M. Bieb.), to test how different cool season turfgrass species and Kura clover seeding rates would affect the establishment and flowering of turf/forb seed mixes. We varied *Kura clover* seeding rate into four different turfgrass species treatments: Kentucky bluegrass (*Poa pratensis* L.), hard fescue (*Festuca brevipila* Tracy), tall fescue (*Festuca arundinacea* Schreb.), and perennial ryegrass (*Lolium perenne* L.). Establishment and bloom of Kura clover was significantly higher in trial one for Kentucky bluegrass and hard fescue, and for Kentucky bluegrass in trial two than in perennial ryegrass or tall fescue. Seeding rate of Kura clover did not affect establishment. *The results from this study highlight that turfgrass species can have differential impacts on forb establishment and flowering, and should be considered when designing flowering lawn seed mixtures.* Hard fescue is very similar to several other fine fescue species; these fine leafed fescues have in common several traits (drought tolerance, slow vertical growth rate, excellent winter hardiness) that make them suitable for a lower-input lawn that is attractive to pollinators.

In experiment 2, we studied the effect of mowing height on floral bloom. We investigated the establishment of eight flowering plants with pollinator value (i.e. a plant that provides floral nectar and pollen for visiting insects) when co-seeded with the turfgrass hard fescue (*Festuca brevipila*). The study was conducted at two locations in central Minnesota with substantially different soil types, and the flowering lawns were subjected to two different mowing heights (6.35 cm and 8.89 cm). We monitored these plantings over the 2014 and 2015 growing seasons for vegetative establishment and flowering of selected forbs. Of the eight forbs selected, *Trifolium repens, Prunella vulgaris* spp. *lanceolata, Thymus serpyllum,* and *Astragalus crassicarpus* established in at least one location. Mowing height did not affect vegetative establishment, but had a negative effect on the number of blooms produced by *Prunella vulgaris* ssp. *lanceolata* and *Thymus serpyllum*. Location played a

significant role in vegetative establishment: *Prunella vulgaris* spp. *lanceolata* established in higher numbers in moist loamy soil conditions; *Thymus serpyllum*, and *Astragalus crassicarpus* established in higher numbers in dry sandy conditions. *This study represents an important first step in identifying appropriate plants and management practices that could be applied in the diversification of lawns and their value to pollinator conservation.*

In experiment 3, we evaluated the effect of mowing on native forb establishment. We established plots of native plants that we hypothesized could establish and bloom under mowing pressure. These species included *Monarda punctate* (dotted beebalm), *Symphyotrichum lateriflorum* (calico aster), *Coreopsis lanceolata* (lance-leaf coreopsis), and *Astragalus canadensis* (Canada milkvetch), and *Menthe arvensis* to 3" and 8" mowing heights. Only calico aster achieved bloom under mowing pressure, suggesting it may be a suitable species for future investigation in turf lawn mixes. The other four species survived mowing, but never achieved bloom below the designated heights. While these species seem ill suited to turf lawns, they may have some utility in areas under light mowing management, as most species survived frequent mowing. *A lighter mowing regime may allow the plants to bloom above their designated heights before the next mowing event*.

Experiment 4 was designed to assist homeowners in establishing flowers in their own existing home lawns. We investigated the establishment of pollinator forage plants *Trifolium repens, Prunella vulgaris* ssp. *lanceolata*, and *Thymus serpyllum* into mature stands of *Poa pratensis* lawns at two locations in Minnesota. At each location, the existing lawn was subjected to three common methods of pre-seeding disturbance: scalping, aeration, and a combination of both scalping and aeration to test if disruption can aid in forb establishment. All forbs established at higher rates at our location under minimal turfgrass management compared to the more intensively managed site. Responses to disruption varied by site and forb species, except for *T. repens*, which established best when lawns were scalped regardless of location or management. Treatments involving scalping also favored *P. vulgaris* ssp. *lanceolata*, but only in lawns with high management intensity. *T. serpyllum* establishment was favored only when scalping was combined with aeration in the highly managed site. *Our study demonstrates that pre-seeding disruption of mature lawns can favor establishment of pollinator friendly forbs, but that site is an important factor.*

ACTIVITY 2: *Public Demonstration Plots*

Description: Here we outline our outreach activities. With our three-year timeline, we will combine the plot uses so that the research plots used in Activity 1 can also serve as demonstration plots for public viewing.

We will sponsor three Bee Lawn public field day~~s~~, one on the St. Paul campus in June 2016 and two at the Landscape Arboretum in the summer of 2015. We will target homeowners, turf professionals, beekeepers, parks and ground managers across the Twin Cities greater metro and extension educators throughout the state. Visitors will be introduced to the concept of a bee lawn, and will be shown the different turf-floral mixtures. We anticipate that some will prefer more turf than flowers to reduce encountering bees while using the lawn. Others that maintain a lawn for aesthetics, rather than function, might prefer a higher density floral mixture in the turf. We will discuss with the public our research progress on species composition, turf quality, disease incidence, bee visitation rates, and bee species abundance and diversity.

Because of the large public visitor base at the Landscape Arboretum (approximately 350,000 annual visitors) this site is ideal for public demonstrations. Dr. Mary Meyer working with a student summer intern at the Arboretum will create signage and maintain the demonstration sites, and will develop educational materials on growing and maintaining bee lawns. The public field days (open houses) will reach a wide audience at the Arboretum and in St. Paul.

As described in the Dissemination section below, we will create a Bee Lawn web page on the Minnesota Landscape Arboretum website, and will also provide new web content related to this project on both the University of Minnesota Bee Lab and Turf sites that describes the bee lawn options and gives research updates. We will also produce a brochure that will be developed in consultation with Arboretum staff; this brochure will be provided to Arboretum visitors as well as participants at the St. Paul field day in 2016. Brochures will also be available to visitors of the University of Minnesota Department of Horticultural Science Display and Trial Gardens on the St. Paul campus (this is a free venue that is located close to large urban populations). We will also develop other resources that will be made to available to the public through the Arboretum and other websites associated with this project. Additionally, at the Arboretum site, we will display a Quick Response code (or similar technology) on primary signage at the plots so that the public can access information about the research when visiting the Arboretum.

Finally, we will use develop virtual tours of the research plots that can be viewed on the Bee Lab and Turfgrass science websites. We have utilized virtual research demonstrations in the turfgrass science program for

our fall 2012 field day (see: turf.umn.edu/home/). Our experience in this area will allow to us to improve our delivery and use feedback from stakeholders to improve the virtual experience. The primary delivery system for this virtual tour will be video (with additional information such as plot maps and location information linked on the website), but we will also explore other options as new technologies arise. For instance, Watkins (CoPI) is currently working on the use of augmented reality for teaching plant science. Augmented reality would allow someone that is visiting a research plot with a smartphone or similar web-connected device, to view additional information on that smartphone while at the plots. The additional information can be overlaid onto the view of the plots that is seen through the devices camera. The augmented reality platform will utilize location information (GPS) and image analysis (what the camera on the phone is seeing) to determine which information to display at any given time. This is an exciting new way to interact with the public, and the bee lawn plots will be a great venue for this type of delivery system.

In addition to M. Meyer and the summer intern, G. Reuter (Technician for Bee Lab, who is primarily responsible for coordinating and teaching all public beekeeping short courses) will assist with all field days and other educational programming, and with web site updates. A part-time undergraduate student (academic year appointment) will assist with development of video production for the virtual tours. As with Activity 1, we anticipate needing time beyond 2 years to complete materials for Dissemination and outreach programming.

Summary Budget Information for Activity 2: **ENRTF Budget: $25,966**
Public Demonstration Plots **Amount Spent: $16,074**
Balance: $ 9,892

Activity Completion Date: June 30, 2016

Outcome	Completion Date	Budget
1 *Research/ demonstration plots viewed at Field Days / Open Houses*	Sept 30, 2015	$10,027
2. *Fact sheets, brochures and planting recommendations*	June 30, 2016	$7,000
3. *Virtual tours and other activities led by student intern*	June 30, 2016	$8,939

Project Status as of: January 2014
Project Outreach Goals

With the social aspects of lawns and bees playing such an important role in this project, we also plan to incorporate a number of outreach projects. These projects will include field days that will allow people to view and ask questions about the bee lawn research. These events will be advertised through the University of Minnesota Turf and Bee research lab web sites and resources.

In addition we will also create a web site focusing on the research for this project that will inform visitors of the different aspect of the project as well as why it's important. This site will be a great way to disseminate other information as well, such as how different home weeds and flowers could play a role in helping honey bees, and offer links and advice to other ways of helping pollinators in urban settings.

Project Status as of: September 2014

In the summer of 2014 research related to this project has been showcased at two separate field days (Minnesota Turf and Grounds Field Day at the University of Minnesota; Urban Forestry Outreach and Research Field Day), The research also the focus of a video developed as part of a virtual field day during fall 2013 (available at turf.umn.edu). In addition we have given two public talks in which the value of flowering forbs in lawns were discussed. The project concept was also introduced in the form of a poster at the American Beekeeping Federation prior to summer 2014.

Project Status as of: March 2015

Since September 2014, research pertaining to this project has been showcased at a number of local venues and events. In November 2014, graduate student Ian Lane presented a poster related to this research at the National Entomological Society of America meeting. Also in November, Ian Lane presented a public seminar pertaining to bee lawn research to the Department of Entomology where he outlined the goals of the project as part of the requirements for his Masters degree. In addition, he presented current goals and progress in a lecture format to students taking turf grass management courses.

Outside of academic circles Ian lane presented an hour-long talk regarding the importance of this project at "Super Tuesday", the event preceding the Green Expo at the Minneapolis Convention Center. He will also give a presentation at the MN Landscape Arboretum for Earth Day describing methods used for establishing the lawns, and more talks at the Arboretum planned this summer. M. Spivak presents information and status updates on the Bee Lawn project at all public talks and venues and receives lots of positive feedback and encouragement. Many people are waiting for the results of this research, and are excited about planting a Bee Lawn on their property. Finally, we have hired Sarah Wisdom as an intern at the Arboretum to help with the establishment of demonstration plots and to assist in the design of educational material and web resources.

Project Status as of: **September 2015**

Since March 2015, graduate student Ian Lane has presented a poster about this project at the American Public Gardens Conference in June, and presented hour long talks regarding the importance of the bee lawn research at two events at the Minnesota Landscape Arboretum: an Earth Day event targeting homeowners for education about sustainable turf practices, and the statewide Master Gardner conference. Ian has also participated in a field day for St. Paul parks employees about best management practices for public park care. He was just awarded the "Master's Achievement Award" through the Entomological Society of America's (ESA) plant-insect ecosystem section. This is the largest section of the ESA and involves a public award ceremony. This will increase the projects exposure at the national research level.

In June 2015, a student summer intern was hired who planted a public demonstration Bee Lawn at the Minnesota Landscape Arboretum showing 5 methods of establishment of three forbs and fine fescue grass that homeowners could replicate. The 5 large, 15 feet x 50 feet plots are visible from the main drive in the Arboretum and have a large sign with information regarding the demonstration. We held two public Bee Lawn Open House events on July 16, 2015 from 4:00-6:00 PM and July 18, 2015 from 10:00 AM-2:00 PM at the Bee Lawn demonstration site at the Arboretum. Approximately 40 people attended each event. We distributed the information that is online under Demonstration Gardens at the Arboretum's website, under Bee Friendly Lawn Area; see: http://www.arboretum.umn.edu/demonstrationareas.aspx. for the ***Help Pollinators by Planting a Bee-Friendly Lawn*** recommendations. Arboretum staff were informed about the Bee Lawn at staff meetings, the reception staff were sent emails and given the ***Help Pollinators by Planting a Bee-Friendly Lawn*** recommendations. In July Mary Meyer spoke to the 30 Arboretum Tour Guides and Tram Drivers about the Bee Lawn demonstration area and how homeowners could do this on their property.

Project Status as of: March 2016

Originally we planned to add QR codes to our Arboretum signage for additional information for the public. Based on research at the Arboretum on other signage and QR code work, few people have used this technology in the outdoor setting at the Arboretum and we have decided not to pursue this feature, due to the low public usage.

Virtual tours (concise 3-5 minute videos describing the plots and how to establish them) of the bee lawn plantings at the Arboretum and on the St Paul campus are planned for May and June 2016, weather permitting, and will be posted on the bee lawn website by the end of the project.

Since September 2015, graduate student Ian Lane has presented results from this research at both the Entomological Society of America meeting, in the form of a talk, and at the Crop Science Society of America meeting, in the form of a poster. Ian also addressed the Minneapolis Parks and Recreation governing board to help generate interest in the application of this project in public areas.

Final Report Summary:

Field days: In the summer of 2014 we presented Activity 1 findings at two field days; one at the Minnesota Turf and Grounds Field Day at the University of Minnesota, and the other at the Urban Forestry Outreach and Research Field Day. In 2015, we held two public Bee Lawn Open House events at the Arboretum at the Bee Lawn demonstration site. Approximately 40 people attended each event. In 2016, we hosted a free, public Bee Lawn Field Day to show the demonstration plantings on the St. Paul campus and provide education on bee or flowering lawns. Approximately 100 people attended and took part in several tours and hands on demonstrations of the plantings for flowering or bee lawns. Evaluations from attendees are included as an Addendum to this report.

Signage: Dr. Mary Meyer worked with student summer interns at the Arboretum to create signage and maintain the demonstration sites. The sites showed 5 methods of establishment of three forbs and fine fescue grass that homeowners could replicate.

Website: A website within the Bee Lab at the University of Minnesota was developed with information on planting and maintenance of Bee or Flowering Lawns. Educational information is provided on the flowering species that can support pollinators in lawns, how the demonstrations were planted at the St. Paul campus and at the Arboretum along with recommendations for establishing and maintaining flowering species in an existing or new lawn. The Flowering Bee Lawn website is: https://www.beelab.umn.edu/bees/beelawn.

Brochure: A Bee or Flowering Lawn brochure was developed; 3,000 copies were printed and were used as a handout at the June 9, 2016 Field Day. This brochure is available at the Minnesota Landscape Arboretum and distributed to the public. The brochure gives additional information on the Bee Lawn demonstration planting at the Arboretum and directions for using flowering species in a lawn and where to obtain further information.

QR Codes and virtual tours: We did not complete these objectives (see Remaining Balance).

Remaining balance for this Activity

We did not spend $9,892 of the original amount budgeted for Activity 2. Our original budget contained $8,939 for adding QR codes to the Arboretum signage about the bee lawns, but due to feedback on low public usage, we decided not add these codes. We also did not produce short videos (virtual tours), but will re-evaluate their utility for Phase II of this project.

V. DISSEMINATION:

Description:

We will update the research through both the bee research website (beelab.umn.edu) and the turfgrass science website (turf.umn.edu). In both cases, we will post occasional research blog updates, post important data, and produce slideshows or videos that show the important research that is being conducted. Upon completion of the research, we will publish research results in peer-reviewed research journals. Both the bee research program and the turfgrass science program have been interviewed by multiple media outlets (in the case of the bee research program, many national outlets) and we expect that these opportunities would also serve as outlets for information on bee lawns. At the conclusion, we will seek additional opportunities for demonstrating our research results in larger scale plots and publishing results in consumer-friendly formats.

In future years, we can broaden our outreach activities to include education to MNDOT for roadside plantings that require mowing, and conferences for grounds managers and urban landscape companies to incorporate bee lawns on their sites. These activities could be held at the Landscape Arboretum, and include a tour of the plots. The Arboretum and the St. Paul campus could provide continuing promotion and publicity for bee lawns in the future.

Project Status as of: January 2014

Nothing to report.

Project Status as of: September 2014

Besides aforementioned field days and outreach talks, dissemination is still pending replicated results. Web presence is in development, but not yet available.

Project Status as of: March 2015

Since November of 2014, Ian Lane connected with Sarah Jordon of the Xerces Society and provided information in designing orchard row clover strips using the results of our research. In addition, Ian Lane wrote about this research for the magazine “Golfdom” describing our goals to the golf course superintendent audience. Ian Lane has been active in communicating our research progress to many seed producers in the Twin Cities area looking to create seed mixes for flowering lawns. Progress on outreach documents and web presence will be accelerated with the hire of Sarah Wisdom this summer.

Project Status as of: September 2015

The Minnesota Landscape Arboretum demonstration Bee Lawn is seen by hundreds of people each week. October is one of the largest months for visitors and the Bee Lawn is very visible along the main drive in the

Arboretum. A group of 25 members of the Lake Minnetonka Garden Club came to the Arboretum on July 16, 2015 to see the Bee Lawn and toured the plots and were given the ***Help Pollinators by Planting a Bee-Friendly Lawn*** information sheet. The Arboretum Tour Guides and Tram Drivers have been given information about the Bee Lawn and are sharing this information with Arboretum visitors.

Project Status as of: March 2016

The signage and bee lawn at the Arboretum are on display and easily visible from Three Mile Drive. The receptionists at the Arboretum know about the project and tell anyone that asks. Due to winter weather and snow cover, there has not been a lot of activity at the bee lawn at the Arboretum. We are in the process of planning a June 2016 field day on the St. Paul campus that will highlight the bee lawn research. A final date will be set once we have a good sense of when important species will be in bloom.

Final Report Summary

We have reached a broad audience with research-based information about bee lawns. Professional audiences have been reached through articles in trade journals. Hobbyist audiences have been reached through presentations at local, regional, and national meetings. Scientific audiences have been engaged through departmental seminars and national scientific meetings. And most importantly, the general public has been reached in a number ways including a field day, a new brochure, and new online content.

A public Bee Lawn Field Day was held on June 9, 2016 to show the demonstration plantings on the St. Paul campus and provide education on bee or flowering lawns. Approximately 100 people attended and took part in several tours and hands on demonstrations of the plantings for flowering or bee lawns. Participants could rotate to hear five different educational sessions: Bee Safari; Landscape Plants for Pollinators; Low Maintenance and Bee Friendly Lawns; Flowering Species for Lawns; and Introducing Flowering Species into Lawns. Evaluations from participants are in an Addendum.

A Bee or Flowering Lawn brochure was developed; 3,000 copies were printed and were used as a handout at the June 9, 2016 Field Day. This brochure is available at the Minnesota Landscape Arboretum and distributed to the public. The brochure gives additional information on the Bee Lawn demonstration planting at the Arboretum and directions for using flowering species in a lawn and where to obtain further information.

A website within the Bee Lab at the University of Minnesota was developed with information on planting and maintenance of Bee or Flowering Lawns. Educational information is provided on the flowering species that can support pollinators in lawns, how the demonstrations were planted at the St. Paul campus and at the Arboretum along with recommendations for establishing and maintaining flowering species in an existing or new lawn. The Flowering Bee Lawn website is: https://www.beelab.umn.edu/bees/beelawn.

During the course of this grant, graduate student Ian Lane participated in over 21 outreach and public speaking engagements that were related to this project. In addition he has presented four academic poster at five different national meetings describing the research done for this grant. At the conclusion of his thesis, which was completed in May 2016, we anticipate three academic papers to result from work conducted while executing this grant. Additionally, professors Marla Spivak and Eric Watkins gave numerous public presentations (over 30) in their normal Extension duties that highlighted this work.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget:

Budget Category	$ Amount	Explanation
Personnel:	$176,440	1 Grad Student Asst, 1 part-time technicians, 0.5 mo summer salary for PI and co-PI, 1 part-time undergraduate, one summer intern
Equipment/Tools/Supplies:	$6,417	Materials to plant and maintain Bee Lawn demonstration plots and collect insects
Printing:	$7,000	Educational materials
Other:	$10,143	Bee Lawn field days and open house on St Paul campus and Landscape Arboretum
TOTAL ENRTF BUDGET:	**$ 200,000**	

Explanation of Use of Classified Staff: Not applicable

Explanation of Capital Expenditures Greater Than $3,500: Not applicable

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: 0.915 FTE

Number of Full-time Equivalent (FTE) estimated to be funded through contracts with this ENRTF appropriation:

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$ 2,000	$2,000	Xerces Society, Project Partner Assistance
	$15,000	$15,000	MacArthur Fellowship Funds, awarded to M. Spivak
State			
	$ 16, 146	$16,146	M. Spivak, 5% salary/fringe cost-share
	$ 10,101	$10,101	E. Watkins, 5% salary/fringe cost-share
	$ 2,693	$0	M. Meyer, 1% salary/fringe cost-share
TOTAL OTHER FUNDS:	**$ 45,940**	**$45,940**	

VII. PROJECT STRATEGY:

A. Project Partners:

Marla Spivak, Professor in Entomology, University of MN: PI will oversee research and outreach, administration of funds, supervise employees and co-advise graduate student; requesting funds. **Eric Watkins**, Assoc. Professor in Horticultural Science will co-advise graduate student, assist with plot establishment, data collection and analysis for Activity 1 and give presentations to stakeholder groups associated with research results from both Activities. Dr. Watkins' research program focuses on the improvement of turfgrasses for use as low-input turf in cold climates; requesting funds. **Mary Meyer**, Professor, Horticultural Science, will provide public education and demonstrations at Arboretum for Activity 2; requesting funds. **Eric Mader**, Adjunct Asst. Extension Prof and Pollinator Program Director, Xerces Society for Invertebrate Conservation, will offer native plant species suggestions and create education materials, deliverable to audiences nationwide through the Xerces Society for Invertebrate Conservation website; providing in-kind support –see attached letter.

B. Project Impact and Long-term Strategy:

The Bee Squad, a fee-based program, was launched by Dr. Marla Spivak within the University of Minnesota Bee lab in April, 2012 to provide hands-on assistance to urban beekeepers in the Twin Cities area (www.beelab.umn.edu). The goals of the program are to: 1) provide personalized, hands-on training for new and experienced beekeepers during key times over the beekeeping season; 2) provide full beekeeping service for home and land owners that want bee hives on their property but do not want the responsibility of managing the bees (e.g., the Bee Squad will maintain a hive for President and Karen Kaler at Eastcliff); and 3) collect information on bee health in the Twin Cities area to feed into national bee health databases and educational programs. Beginning in 2014, we will add programming to provide landscape designs and assistance in planting bee-friendly gardens to increase the availability of habitat for honey bees and native bees. In 2015, we hope to add recommendations for planting bee lawns. Through the Bee Squad program at the University of MN, the exceptional educational opportunities through the MN Landscape Arboretum, and the excellent national reputation of the Xerces Society for leading changes in public practice and policy to protect pollinators, we expect that bee lawns will be promoted through the state and nationally.

C. Spending History:

Funding Source	M.L. 2007 or FY08	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13

(add or remove rows and columns as needed)

VIII. ACQUISITION/RESTORATION LIST:

IX. MAP(S):

X. RESEARCH ADDENDUM: This project involves both applied research and outreach. We have considerable research expertise in bees (M. Spivak), turf (E. Watkins). However we will consult and work closely with partners and colleagues (Xerces Society Pollinator Specialists Eric Mader and Mace Vaughan, Prairie Restoration owner Ron Bowen and Landscape Arboretum personnel, Mary Meyer) that will peer–review our research as we implement it.

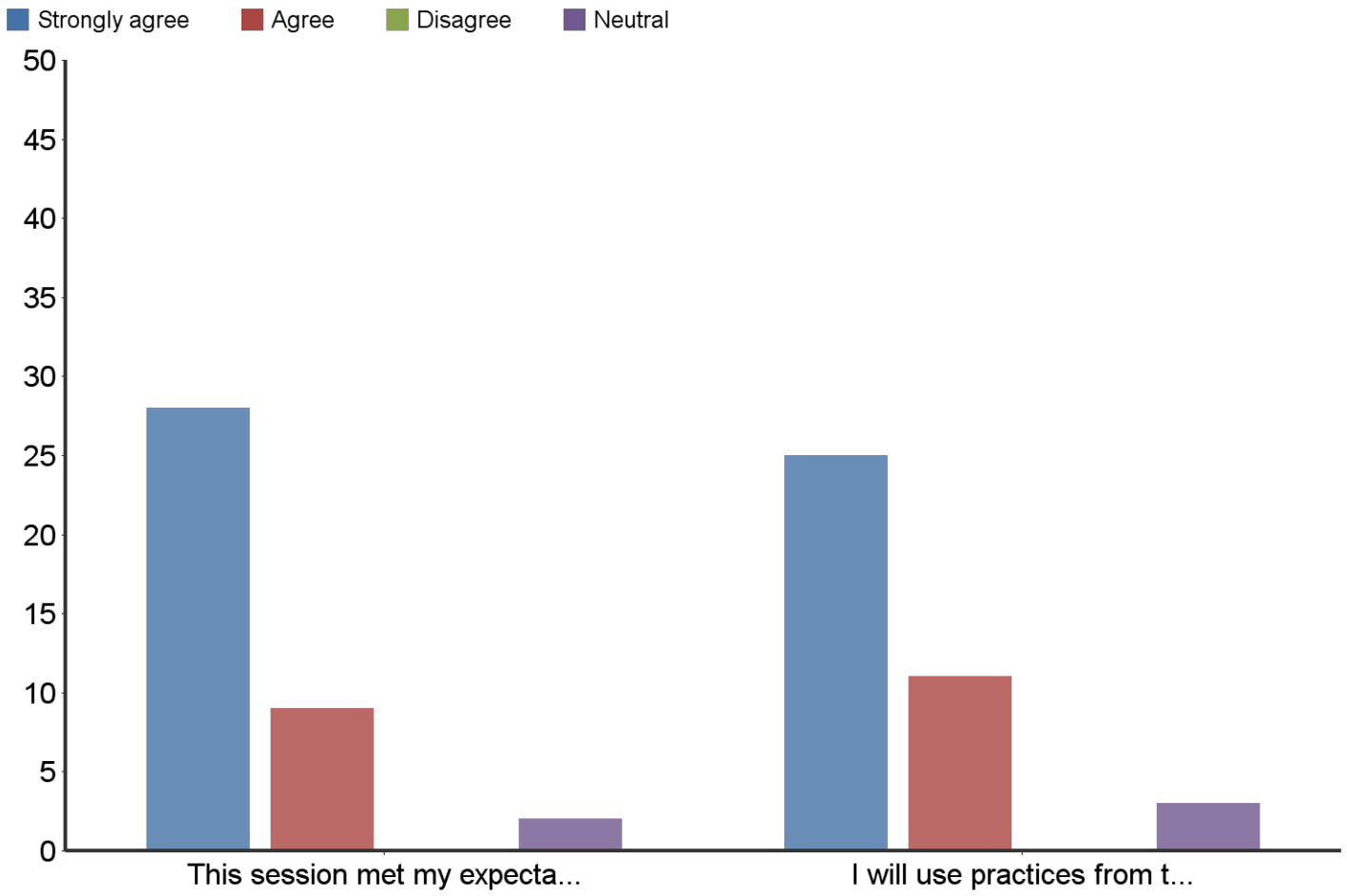
XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted not later than January 2014, September 2014, March 2015, September 2015, and March 2016. A final report and associated products will be submitted between June 30 and August 15, 2016 as requested by the LCCMR.

FINAL Attachment A: Budget Detail for M.L. 2013 Environment and Natural Resources Trust Fund Projects

Project Title: Bee Pollinator Habitat Enhancement
Legal Citation: ***M.L. 2013, Chp. 52, Sec. 2, Subd. 04h***
Project Manager: Marla Spivak
M.L. 2013 ENRTF Appropriation: $ ***200,000***
Project Length and Completion Date: ***June 30, 2016***
Date of Amendment: October 23, 2015

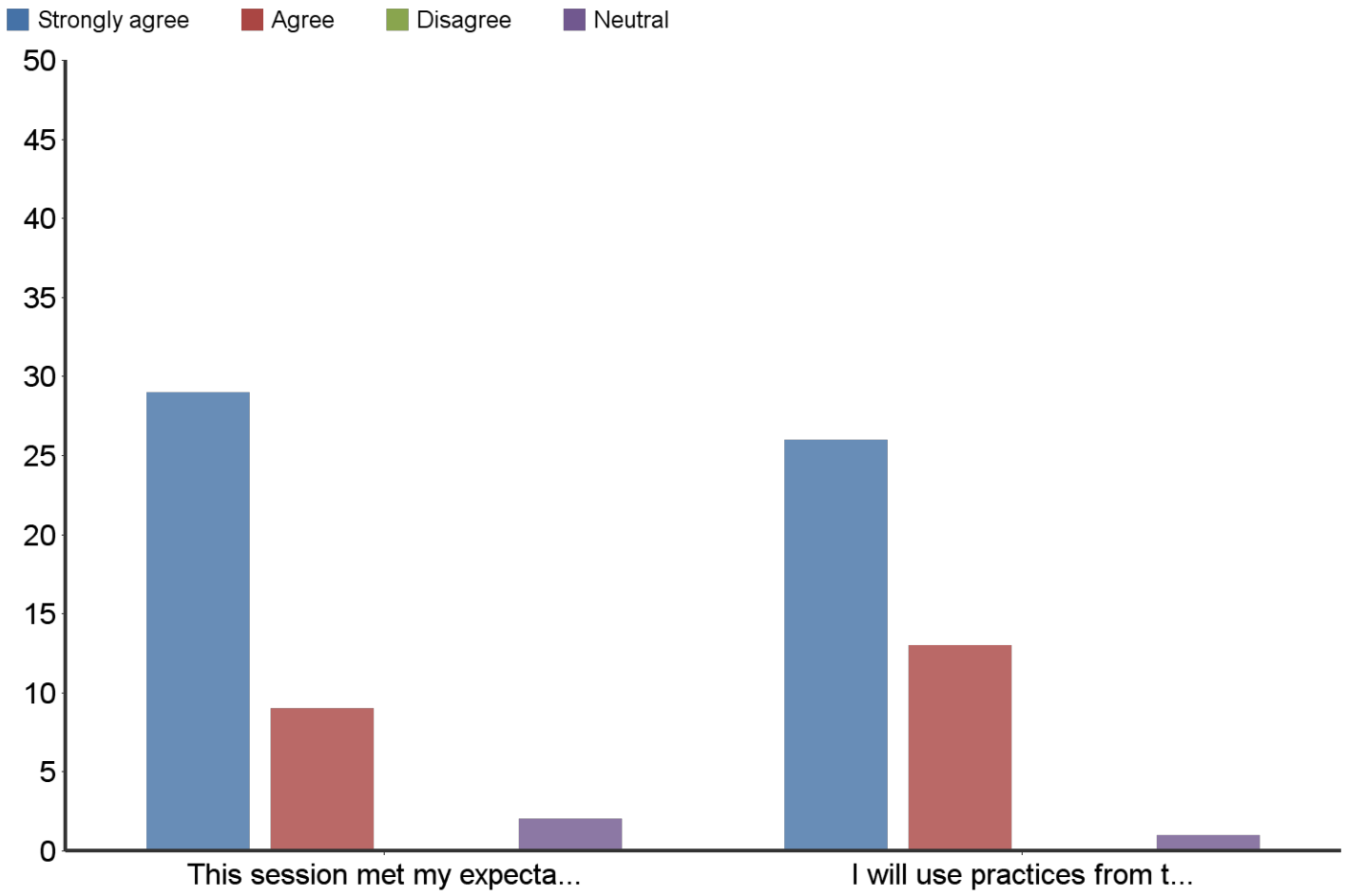
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Activity 1 Budget 10/26/15)	Amount Spent	Balance	Revised Activity 2 Budget 10/26/15)	Amount Spent	Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM								
Personnel (Wages and Benefits)* (see footnote)	167,501	167,501	0	8,939	8,939	0	176,440	0
Marla Spivak, Project Manager, $17,602 (0.5 mo summer salary, 7% fringe benefits + 3% inflation) 0.05 FTE								
Eric Watkins, Project co-manager, $19,013 (1 mo summer salary, 7% fringe benefits + 3% inflation) 0.11 FTE								
1 Graduate Research Assistant (Masters degree), $85,898 (academic year and summer salary, fringe benefits and tuition +3% inflation) 0.50 FTE								
Gary Reuter, Bee Technician and Outreach, $21,254 (15% salary, 39.6% fringe + 3% inflation) 0.15 FTE								
Andrew Hollman, Turf Technician, $28,514 (15% salary, 39.6% fringe + 3% inflation) 0.15 FTE								
Undergraduate, Academic year, $16,475($10/hr, 10 hr/ wk)								
Summer intern at Arboretum, $4,667								
Equipment/Tools/Supplies Costs are estimates. Actual costs will be billed	6,417	6,417	0				6,417	0
Seed (estimated $500)								
Fertilizer (estmiate $226)								
Biodegradable seed germination blankets (estimated $2376)								
Soil probes (not needed, nothing estimated)								
Insect nets, bowl traps, pins and labels (estimated $3000)								
Printing *Educational materials: signs, website work, brochures, handouts, pubs, press releases, fact sheets, online updates, references, making your own Bee Lawn*				7,000	3,075	3,925	7,000	3,925
Lab Services *Soil Lab analysis* **(01/15/2014)**	116	116	0				116	0
Travel expenses in Minnesota								
Other *Open House Bee Lawn Days (educational tours onsite, St Paul campus and Landscape Arboretum)*				10,027	4,059	5,968	10,027	5,968
COLUMN TOTAL	**$174,034**	**$174,034**	**$0**	**$25,966**	**$16,074**	**$9,892**	**$200,000**	9,892

Session 1: Low maintenance turfgrasses (Eric Watkins and Sam Bauer)



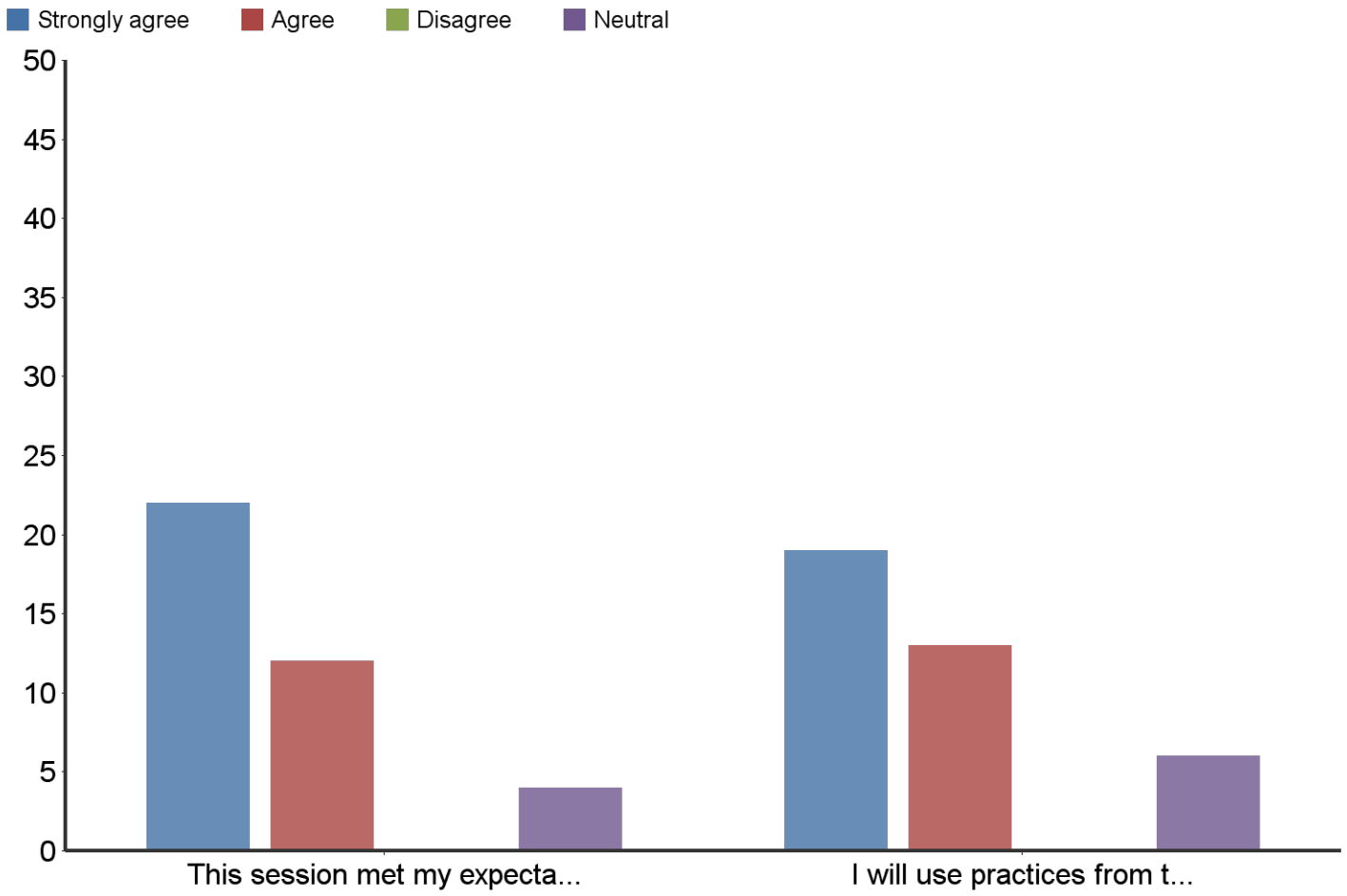
#	Question	Strongly agree	Agree	Disagree	Neutral	Response	Average Value
1	This session met my expectations	28	9	-	2	39	1.38
2	I will use practices from this presentation at my property	25	11	-	3	39	1.51

Session 2: Flowering plants for lawns (James Wolfin)



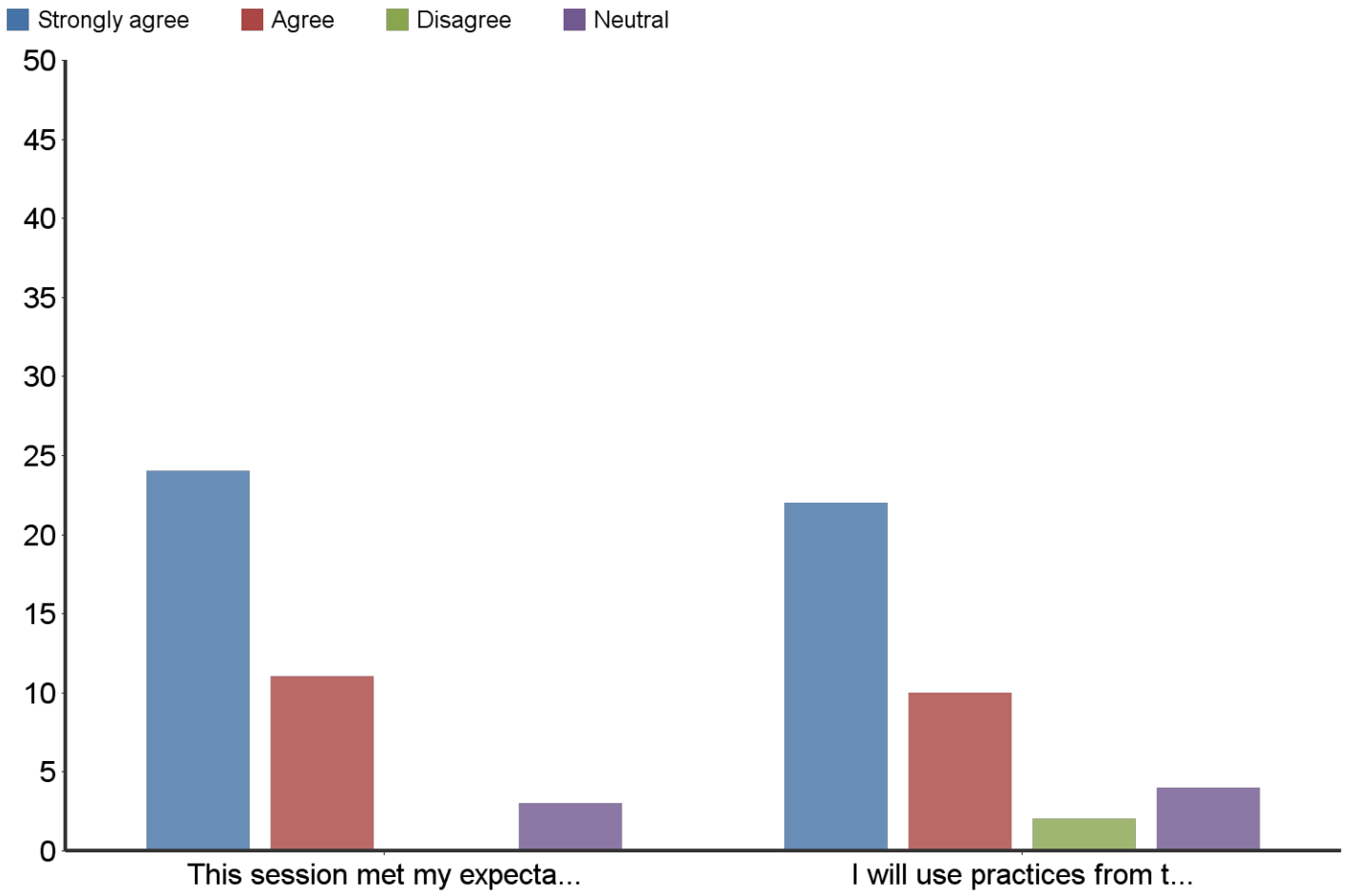
#	Question	Strongly agree	Agree	Disagree	Neutral	Response	Average Value
1	This session met my expectations	29	9	-	2	40	1.38
2	I will use practices from this presentation at my property	26	13	-	1	40	1.40

Session 3: Introducing flowering species in lawns (Andrew Hollman and Jon Trappe)



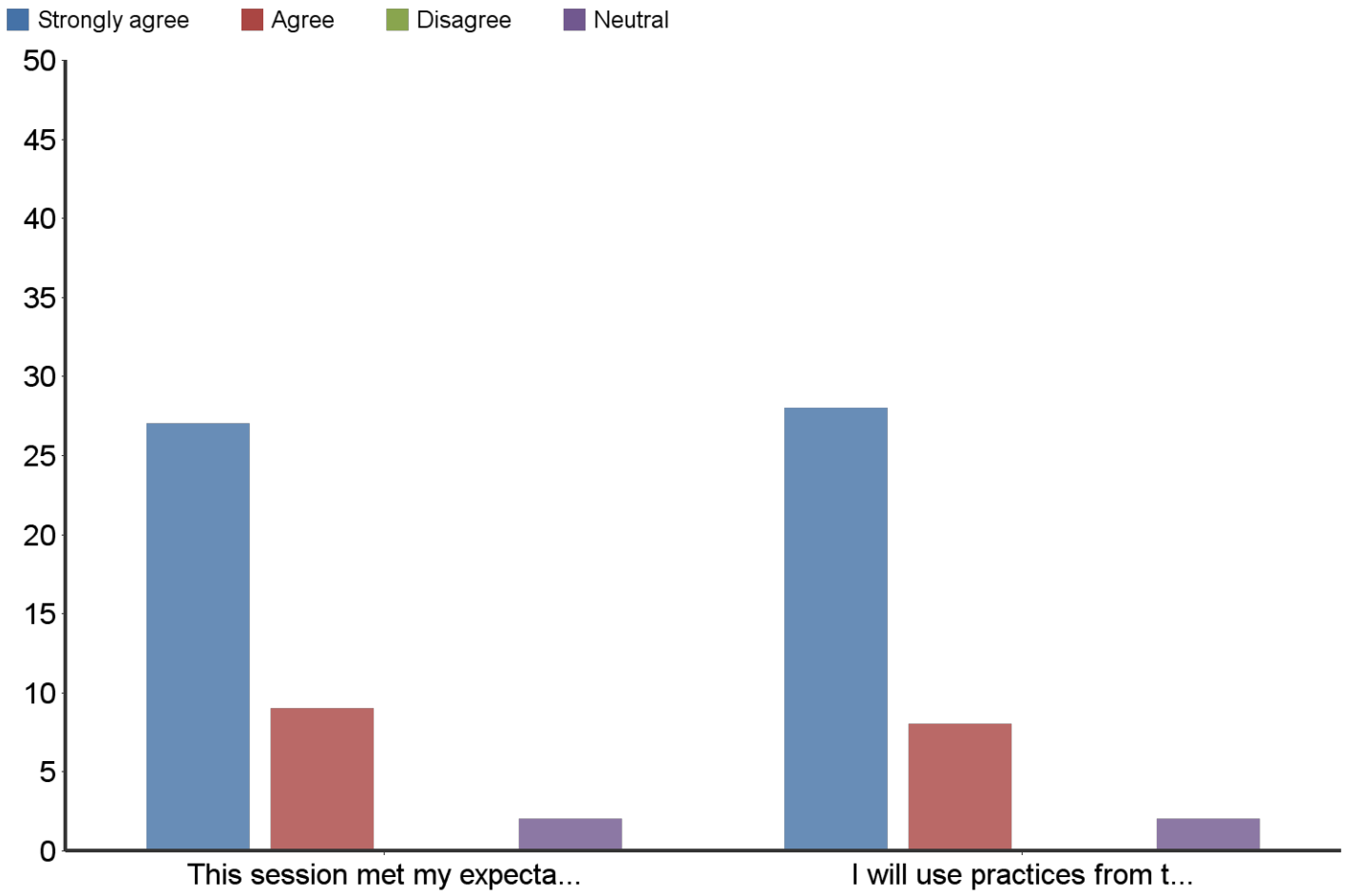
#	Question	Strongly agree	Agree	Disagree	Neutral	Response	Average Value
1	This session met my expectations	22	12	-	4	38	1.63
2	I will use practices from this presentation at my property	19	13	-	6	38	1.82

Session 4: Bee Safari (Elaine Evans)



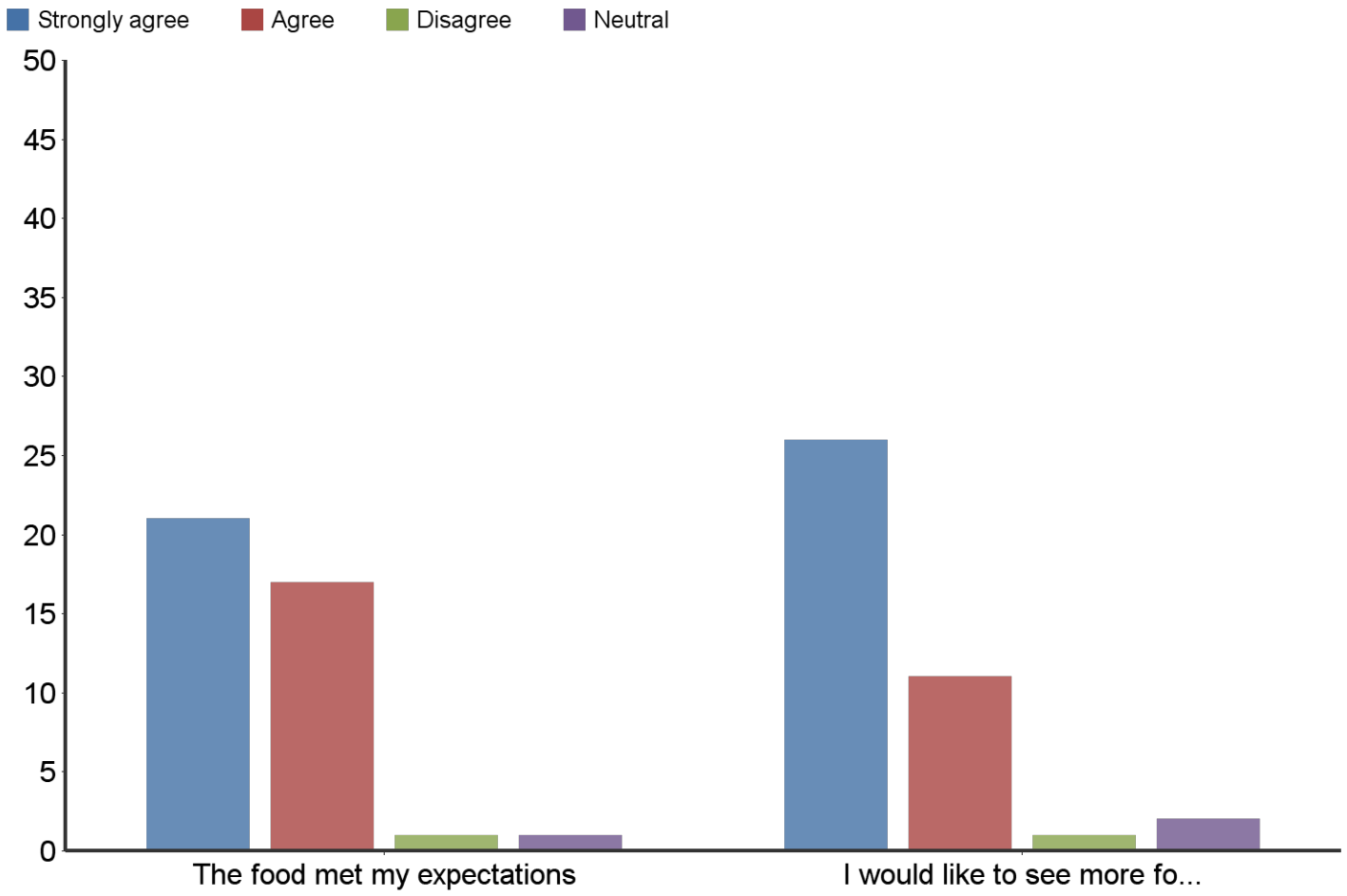
#	Question	Strongly agree	Agree	Disagree	Neutral	Response	Average Value
1	This session met my expectations	24	11	-	3	38	1.53
2	I will use practices from this presentation at my property	22	10	2	4	38	1.68

Session 5: Landscape plants for pollinators (Ian Lane)



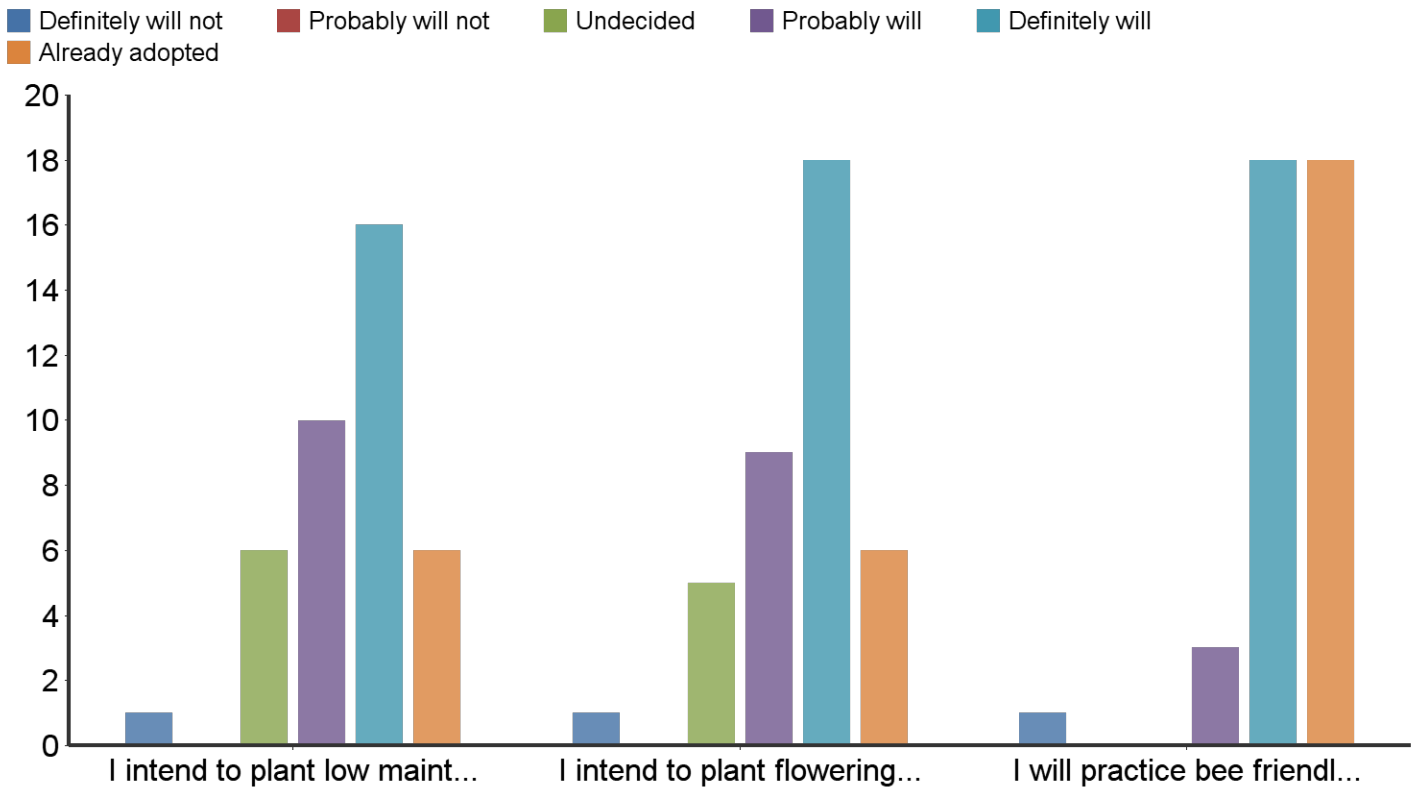
#	Question	Strongly agree	Agree	Disagree	Neutral	Response	Average Value
1	This session met my expectations	27	9	-	2	38	1.39
2	I will use practices from this presentation at my property	28	8	-	2	38	1.37

Food Truck: FunFare- Global Street Eats



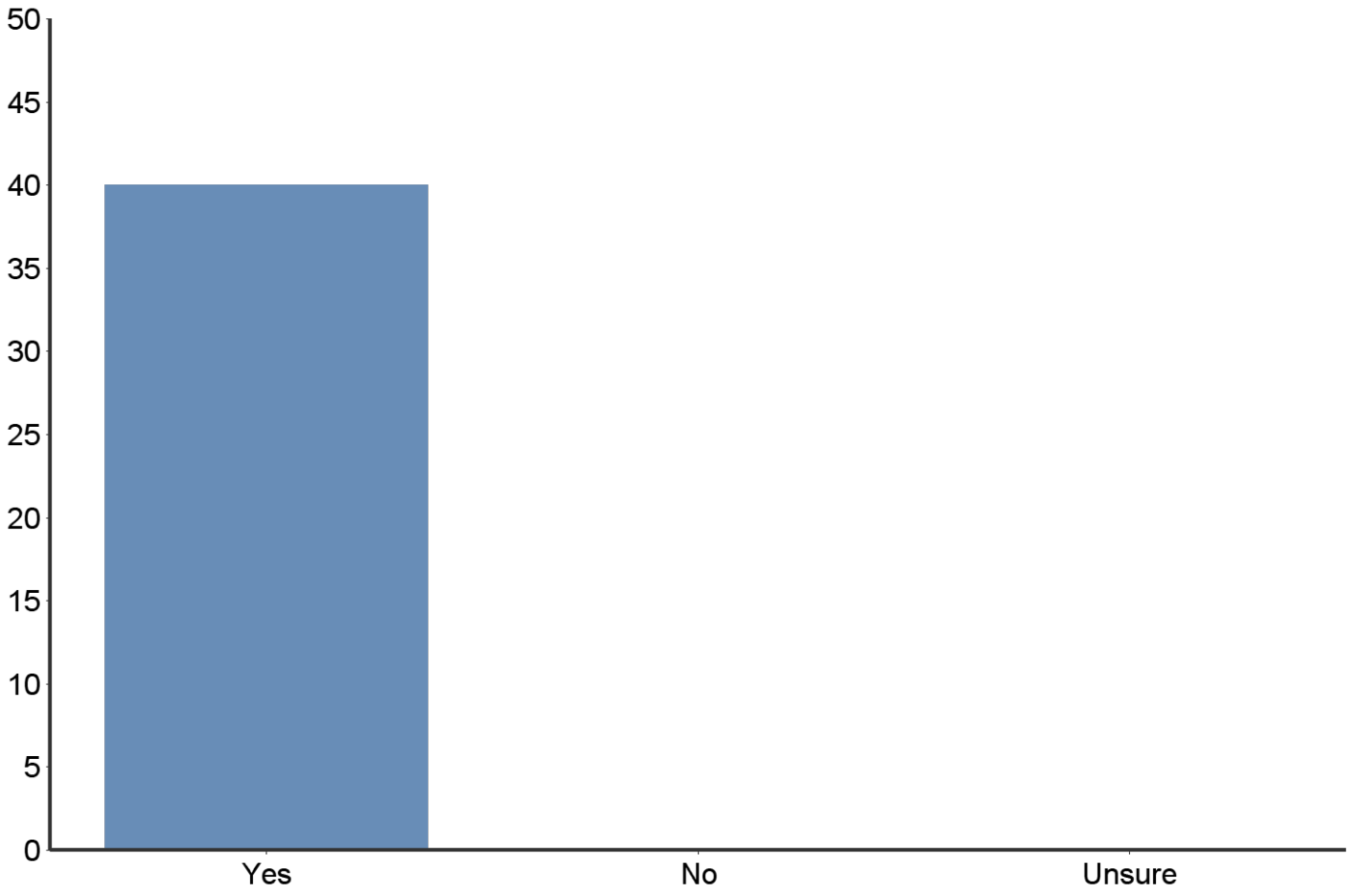
#	Question	Strongly agree	Agree	Disagree	Neutral	Response	Average Value
1	The food met my expectations	21	17	1	1	40	1.55
2	I would like to see more food trucks at future field days	26	11	1	2	40	1.48

Please indicate your intentions to implement the following practices



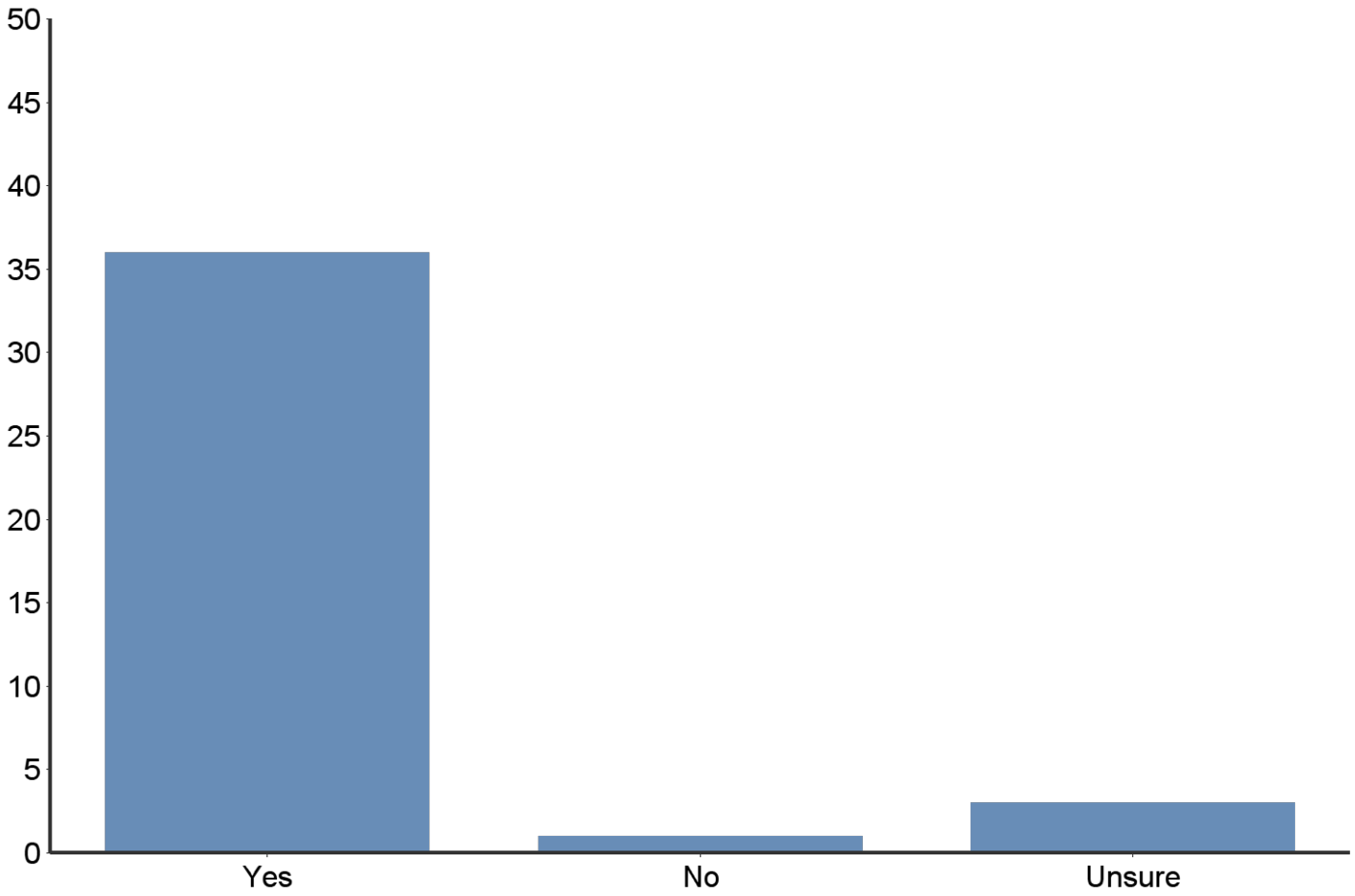
#	Question	Definitely will not	Probably will not	Undecided	Probably will	Definitely will	Already adopted	Response	Average Value
1	I intend to plant low maintenance fine fescues in my lawn	1	-	6	10	16	6	39	4.49
2	I intend to plant flowering species in my lawn	1	-	5	9	18	6	39	4.56
3	I will practice bee friendly lawn care practices such as reducing the level of pesticides and increasing mowing heights	1	-	-	3	18	18	40	5.28

The information obtained at the Bee Lawn Field Day will make me a better environmental steward.



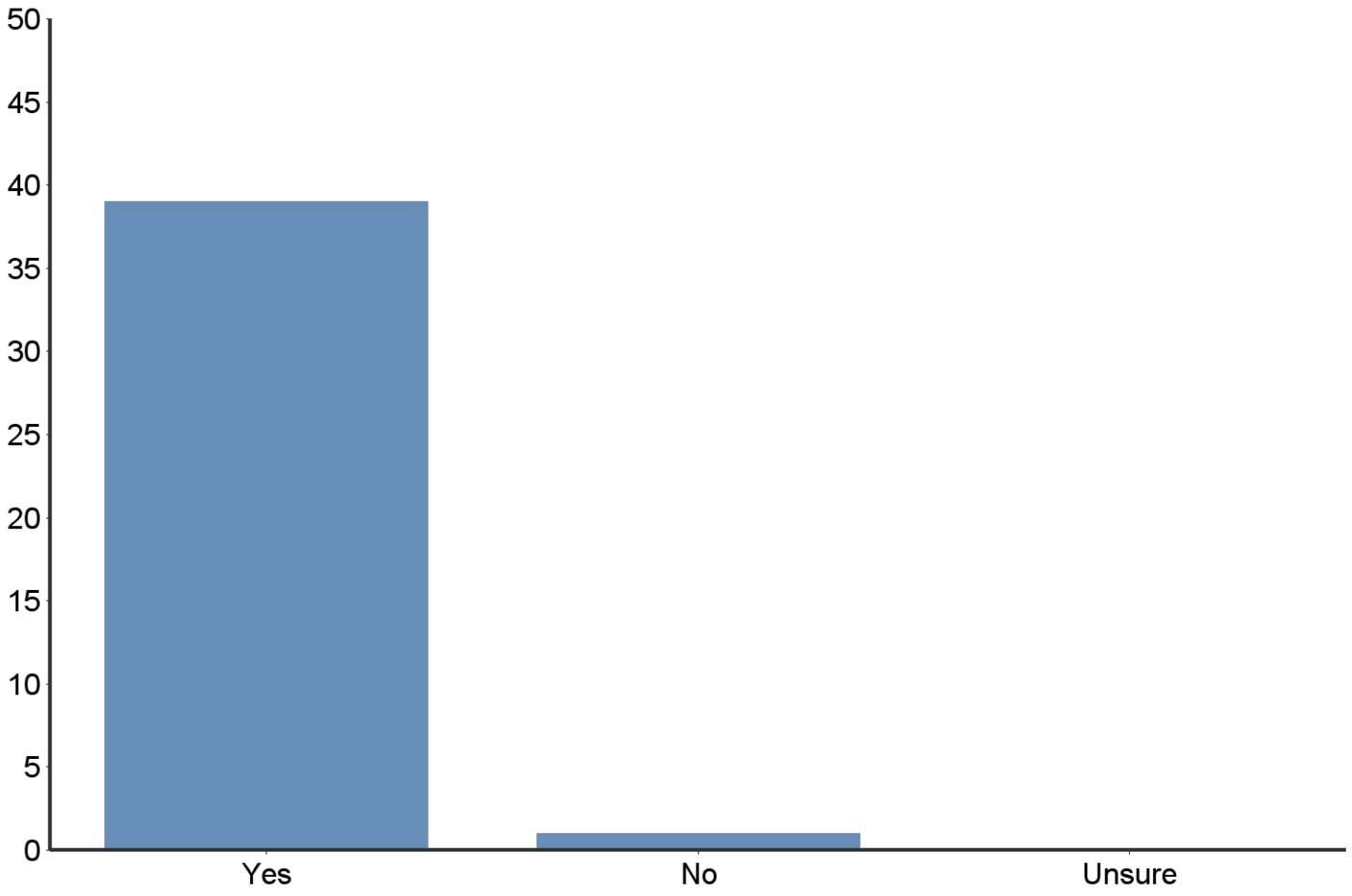
#	Answer	Bar	Response	%
1	Yes		40	100.00%
2	No		0	0.00%
3	Unsure		0	0.00%
	Total		40	100.00%

I will use information from the Bee Lawn Field Day in my everyday life.



#	Answer	Bar	Response	%
1	Yes		36	90.00%
2	No		1	2.50%
3	Unsure		3	7.50%
	Total		40	100.00%

I would like to learn more about what I can do for pollinators.



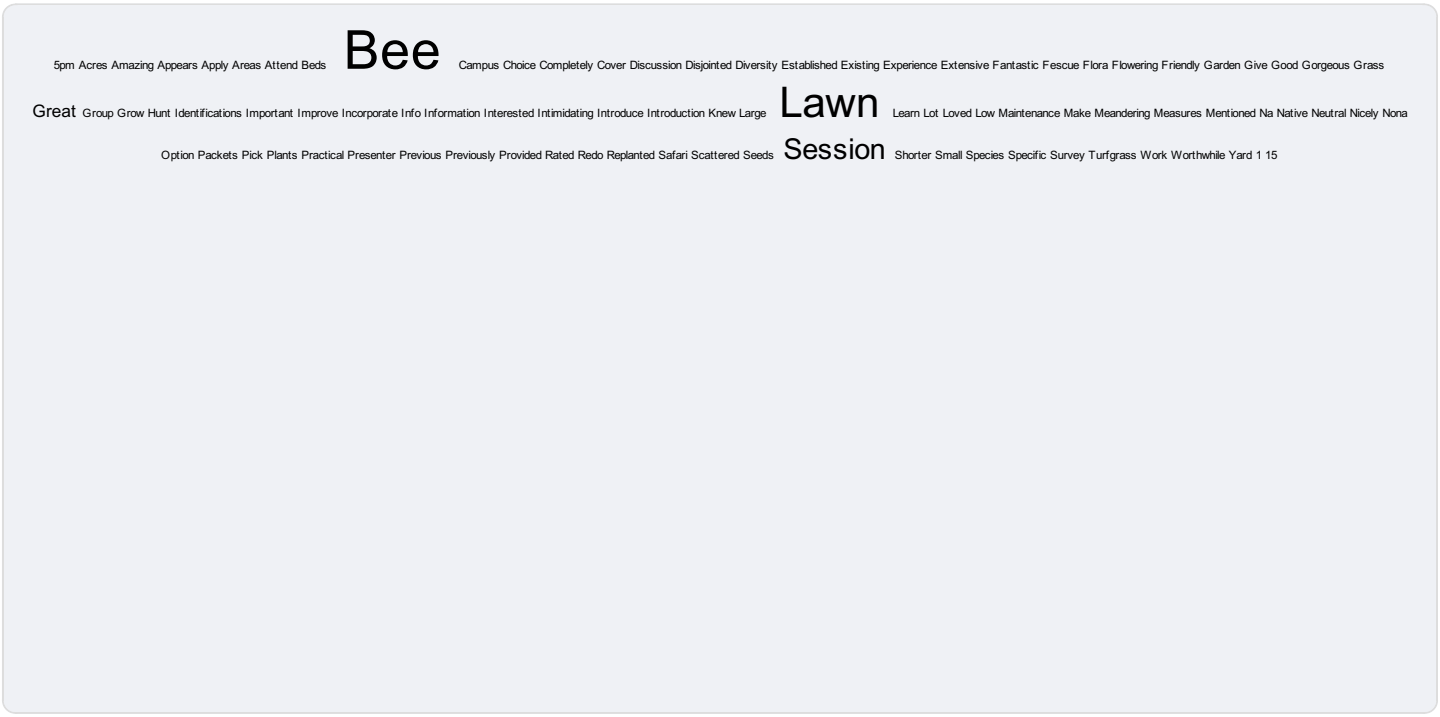
#	Answer	Bar	Response	%
1	Yes		39	97.50%
2	No		1	2.50%
3	Unsure		0	0.00%
	Total		40	100.00%

Which particular session did you find most useful and why?

Text Entry
flowering plants for lawns. Provided direct visual info about specific plants.
Session 3 and 4, i have bees now and i love to plant flowers
The turf portions, mostly because I am familiar with many pollinator practices from previous U of M courses and personal experiences with beekeeping
Not sure there was a particular session that stood out from the rest for me. I learned a lot of useful information at each session.
Bee ID, translates to other applications beyond lawns.
Elaine's session because she described bee habits and that translates nicely to my doing what I can to encourage them.
Session 2- very concrete with specific advice on what to plant and why
Bee plants
Flowering plants for lawns was practical
lawn plants furthered knowledge

View More

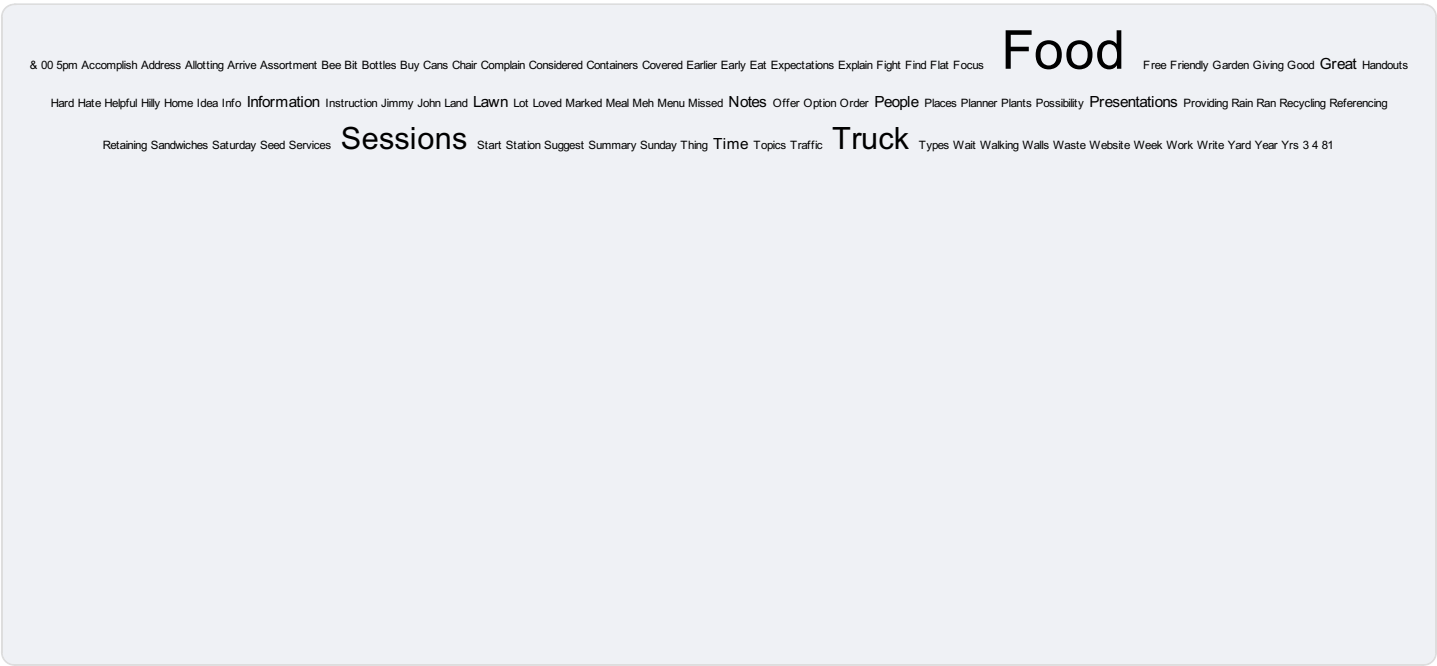
Which particular session did you find least useful and why?



Text Entry
NA. They were all useful.
I liked them all
Session 1, we have a very large yard already established not sure id redo 15 acres of yard.
I loved the bee hunt, but not everyone could learn about the bee identifications because the group was scattered. The diversity in the bees on plants was amazing, so just the experience of meandering the gorgeous garden was worthwhile. Knew it was somewhere on campus, but never knew where!
N/A
Fescue, do not currently have a lawn that could be completely replanted.
Bee safari/ too brief
not apply
Introduction of plants was a little disjointed
Low Maintenance Turfgrasses, the grass seemed like a great choice for a lawn, but the presenter mentioned that fescues won't grow nicely with flora so i wasn't sure why that choice in lawn would be great for a bee lawn...

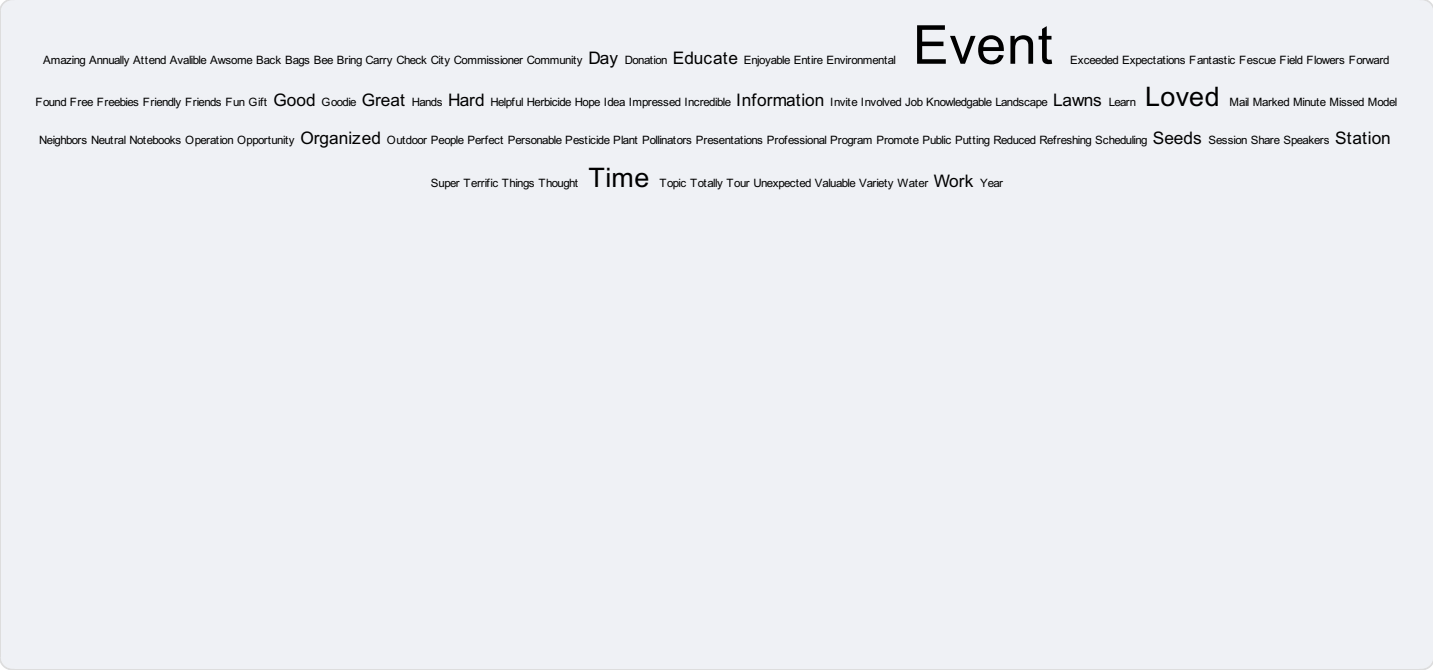
View More

Suggestions for improving the Bee Lawn Field Day.



Text Entry
The handouts & summary info was very helpful for referencing.
Fabulous! I would have enjoyed seeing your hives
I noted a lot of older participants. Perhaps explain that folks should where good walking shoes, as there would be both tractor transportation and lots of walking involved. For some this could present challenges. A formal wrap up session would be great.
My only suggestion is allotting more time. Each of our sessions ran over. Many people had to wait quite a while to get food from the truck and had very little time to eat.
Well done!
A large demo lawn maintained at the recommended height out in the sun would have been very helpful.
Chair at each station (I'm 81 yrs old)
better instruction where-address
Any possibility you could start this a later? I missed 3 sessions because I had to work until 5pm and then fight traffic to get to you. Have you ever considered doing this on a Saturday or Sunday? I loved the idea of having a food truck there and providing food for us. The order early option with menu was also a great idea. I hate to complain because the food was free, but it was just meh. Nothing to write home about, just okay. I would suggest trying a different food truck next year or maybe an assortment of Jimmy John sandwiches.
I didn't realize before I arrived that it would be so structured into rotating presentations. Maybe I didn't read the description very carefully. I thought it worked very well, I just would have liked to understand the format better beforehand.
View More

Please provide any additional comments on the Bee Lawn Field Day.



Text Entry
Perfect day! Very informative. Everyone was very personable.
I loved it!
Thank you for pulling this multi-disciplinary group together - drawing on the expertise of multiple departments was an incredible opportunity for learning. Still not sure how I can plant flowers in my lawn even if the fescue will need mowing, so obvioysly little islands of flowers in the sea of fescue (mass plantings) is probably a good idea. The event was wonderful and for a first-time offering, seemed to go without a hitch. The blow horn timer kept things moving along. The staff was phenomenal. The backdrop of the new research center was inspiring. The living lab experience could never be duplicated in a classroom - so excellent venue. Advise folks to come with notebooks and goodie bags - it got hard to carry all of the totally unexpected freebies around from station to station.
Loved it!! Going to share this information with as many people as I can and hope you invite me back for another day - I'll try to bring friends! Thank you for all your hard work putting this together!
Thank you!
Well organized, liked the station approach, really appreciated the packets of seeds
Great program, hope to see it annually to get more people involved
Amazing-great job!
I thought it was very well organized and very educational!
This was the first time attending and I thought it was fantastic. I will promote the idea of bee friendly lawns to my neighbors and friends and invite this to attend this event next year.

View More

Dutch White Clover
(Trifolium repens)

Creeping Thyme
(Thymus serpyllum)

While **non-native flowers** may be aggressive, they can still be very useful. Dutch white clover *(Trifolium repens)*, and creeping thyme *(Thymus serpyllum)* are two species that benefit pollinators and will flower in a mowed lawn.

White clover provides additional nitrogen and tolerates drought, making it easy to grow in low maintenance conditions.

Dandelions and Creeping Charlie also benefit pollinators but are very aggressive and typically are not favored by homeowners.

MANAGING BEE LAWNS

- **Mowing:** The one-third rule is a good guide: do not mow more than one-third of the vegetation at one time to a height between 3.5 and 4 inches to ensure that flowering plants survive and produce flowers to sustain pollinators.
- **Watering:** Soil moisture should be monitored. White clover and fine fescue grasses are quite drought-tolerant but may need supplemental watering after several weeks with no rain.
- **Fertilizing:** A soil test (visit soiltest.cfans.umn.edu) will determine if nutrients need to be added. Fertilizer requirements will be minimal if clippings are returned, mowing heights are kept high, and soil quality is good.
- **Weeding:** Hand weeding is preferred option, with spot treatments with selective herbicide as needed. Learn what weeds have value to pollinators, are diverse and add to a long flowering season for bees and other pollinators.

Visit Bee Lawn Demo/Trial Plots at the Minnesota Landscape Arboretum, located near shrub garden collection along Three-Mile Drive.

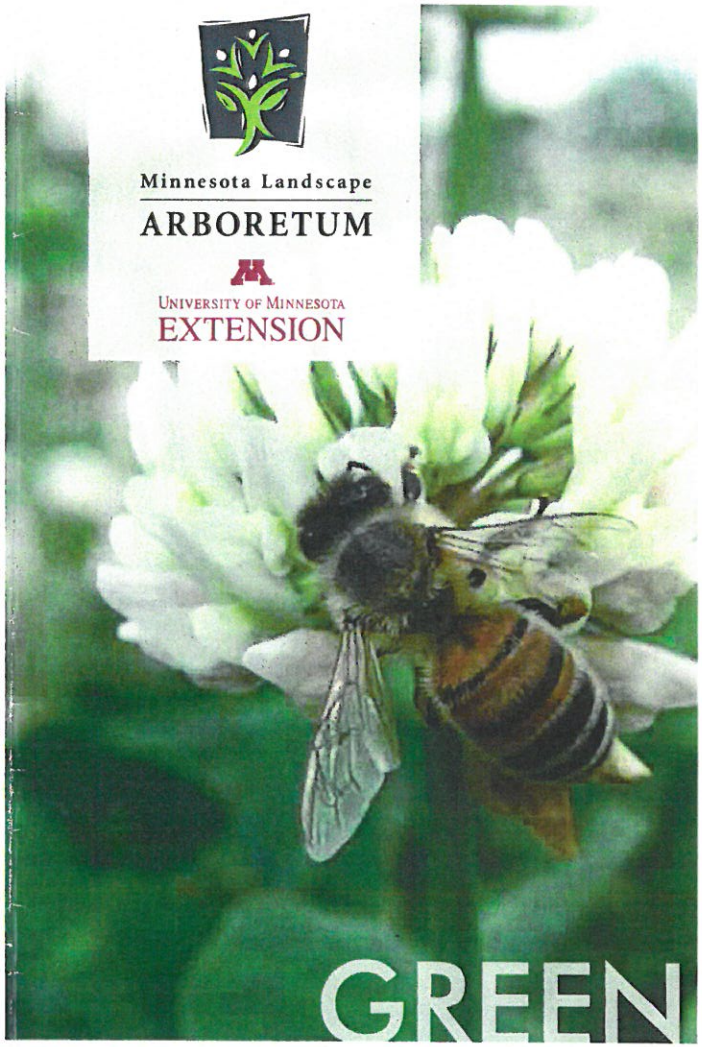
Additional Resources:

- **University of Minnesota Landscape Arboretum**
  arboretum.umn.edu/gardensandcollection.aspx
- **beelab.umn.edu/bees**
- **University of Minnesota Extension:**
  Ian Lane, Eric Watkins, Marla Spivak, and Mary Meyer

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Funding for this project was provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR).

Minnesota Landscape
ARBORETUM
UNIVERSITY OF MINNESOTA
EXTENSION



Bee Lawns
Turf Grass with Flowering Plants

arboretum.umn.edu

UNIVERSITY OF MINNESOTA

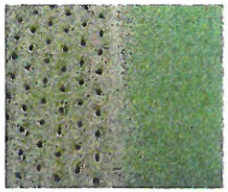
BENEFIT OF BEE LAWNS

Traditional lawns are ornamental or recreational plantings of turf grass that are mowed and managed.

A bee lawn features flowering plants as well as turf grasses, with these benefits to bees and pollinators:

- Natural diversity
- Less mowing, fertilizing and watering
- Beauty of flowers
- Increased resilience to extreme seasonal temperatures, drought

ENHANCE YOUR LAWN TO PROMOTE POLLINATORS



A new lawn planting includes the desired flowers; or you may seed flowers into an existing lawn. Seeding into an existing lawn is more economical but can be challenging to establish, as new flowers compete for space with grass. Satisfactory seed germination requires adequate moisture, good soil to seed contact and erosion protection. Scalping (mowing existing grass to 1 inch or less), aerating and then adding flower seed has proven successful.
For more information visit:
beelab.umn.edu/bees

GRASSES TO USE

Native Fine Fescue: This group of species, including hard fescue and creeping red or Chewing fescues; grow slowly and do not compete against bee-friendly plants. Fescues are main components of shady lawn mixtures but grow well in full sun. Their drought and low fertility tolerance makes them good choices for flowering lawns.

Kentucky Bluegrass:
This popular lawn grass establishes slowly, allowing non-native flowering plants* to grow along with the lawn.

* The use of non-native species in a bee lawn does not meet the Board of Water and Soil Resources' native vegetation establishment and enhancement guidelines, and does not meet project requirements section of the ENRTF appropriation.

NATIVE FLOWERS FOR BEE LAWNS

Through research trials at the University of Minnesota, results show that the best native plants for lawns germinate quickly and adapt to the soil. Native species demonstrating potential include:

- Ground Plum *(Astragalus crassicarpus)*
  A low-growing species in the pea family that is native and common to the prairies of Minnesota.

- Lanceleaf Tickweed *(Coreopsis lanceolata)*
  A late spring bloomer in the aster family.

- Lanceleaf Self-heal
  (Prunella vulgaris ssp. lanceolata)
  In the mint family and is distributed widely in the United States and Europe. There are three self-heal subspecies, with ssp. *vulgaris* being native to Europe and throughout North America, and var. *lanceolata* being native to Minnesota.

- Calico American Aster
  (Symphyotrichum lateriflorum)
  A late blooming flower, typically grows around 3 ft. tall. When mowed, calico aster will form small dense rosettes, blooming below a 3.5 inch cutting height.

Flowering Bee Lawns for Pollinators

Flowering Lawns: What Are They, and Why?

Definition of a flowering lawn

Lawns are traditionally ornamental or recreational plantings of turfgrass that are mowed and managed to achieve a desired aesthetic. While turfgrasses are used for a variety of functions, such as sports fields and erosion control, lawns are typical of homes and businesses and established for generally aesthetic purposes showing neatness and care. A flowering lawn differs from a traditional lawn in having flowering plants as well as turf grasses. Benefits of a flowering lawn include increased lawn resilience to environmental pressures, natural diversity that benefits insects and other animals, and the beauty of the flowers themselves.

Landscape, biodiversity benefits

One of the main challenges facing bees, and all wildlife, is the loss of habitat. People change the landscape in many ways when converting land to different uses, and most of those changes are detrimental to biodiversity. One excellent example of this is agriculture. Farmers often plant large and uniform stands of crops to increase their management efficiency, and then attempt to exclude crop competitors such as weeds and insects. This system, while efficient at producing food, has resulted in increasingly large areas of low quality habitat for wildlife. One method proposed for offsetting this loss of biodiversity is called reconciliation ecology. Reconciliation ecology is a conservation philosophy that seeks to improve the ability of human landscapes to support biodiversity, while still allowing for human use. This is an important concept, as it acknowledges the human role in conserving biodiversity, and seeks to find new management solutions that do not put human use and biodiversity needs in conflict.

Watch Dr. Marla Spivak, professor at the University of Minnesota, discuss the importance of biodiversity and bees in this TED talk Why Are Bees Disappearing.

Lawns are not entirely different from farms in that they are managed as large single or similar species plantings, with chemical inputs sometimes used to reduce non-grass plants usually viewed as competitors. Lawns are unlike much of agriculture though, in that they are perennial in nature and not managed as a commodity. This subjective and changing use of lawns gives

them potential for modification through reconciliation ecology. If we can preserve the human use of lawns while improving their ability to support biodiversity by incorporating flowering plants, we can create a win-win situation or both people and nature.

Your Current Lawn: Flowers or Weeds?

While lawns are usually managed for uniform stands of only grass, flowering plants, often considered weeds, are common and adapted to lawn conditions. Whether introduced or native, many weeds provide pollen, nectar, or both to foraging bees throughout the year.

Pros and cons

While flowering lawn weeds are often seen as a nuisance, they can actually have benefits to lawns in addition to bees. Weeds may be better adapted than turfgrasses to difficult site conditions such as compacted soil, drought, flooding, shade, and low nutrient availability. For example, white clover has been shown in many studies to increase available nitrogen in the soil, due to the symbiotic soil bacteria that live in nodules on clover roots, which turn atmospheric nitrogen into plant available nitrogen. Flowering plants can fill in for grass species in unfavorable conditions to ensure continuous ground cover, which in turn reduces soil erosion and nutrient run off.

The downside to lawn weeds is that many are aggressive, non-native and prone to being invasive in cultivated and natural areas. Non-native plants are good resources for bees with a broad host range, but are typically not good forage for specialized bee species. Many of the most common weed species, such as dandelion, are also widely reviled by homeowners. This "bad rep" can create social pressures to remove weeds even if the lawn manager is tolerant of diverse lawns and realizes how plant diversity benefits pollinators.

How to Enhance your Lawn to Promote Pollinators

Preparing the Lawn

Enhancing a lawn with flowering species can be done through either a new lawn planting that includes the desired flowers or seeding flowers directly into an existing lawn. Seeding into an existing lawn is more economical but can be challenging to get good establishment, as the new flowers must compete for space with the established grass. Good seed germination is critical for both methods, and requires adequate moisture, good soil to seed contact, and protection from flash rain events that could wash seeds away. The University of Minnesota Extension Service has an excellent guideline on lawn renovation through either over seeding or new plantings of turfgrass seed (http://www.extension.umn.edu/garden/yard-garden/lawns/lawn-renovation/). For flowering lawns you need to add flower seed to the above recommendations. If you are interested in seeding flowers directly into your lawn, there are a number of practices that can increase your success.

1.) It is critical to **pick the right flower species** for your site. Consider where the lawn is: Is it in a depression where water pools? Is it in full sun or shade? Also consider the type of soil, which dictates the species that can thrive in your site.
2.) Any seeds sown into an established lawn will need to compete with the grass. The first step is providing enough seed to ensure the plants can become established. In our preliminary trials at the University of Minnesota, 200 seeds/ft.^{2} has worked well for a seeding rate of Dutch white clover (*Trifolium repens*) lanceleaf self-heal (*Prunella vulgaris* ssp. *Lanceolata*) and creeping thyme (*Thymus serpyllum*). If you have a very dense lawn, give the flowers a competitive edge by disrupting the lawn directly before seeding. In our research trials, mowing the lawn very short (1.5 in.) prior to seeding, known as scalping, had the best effects on establishment. Scalping allows more sunlight to hit the soil surface aiding the germinating seeds, and helps to slow the competition of the established grass. This practice is stressful for the lawn grasses, but they should recover barring any extreme stresses such as drought.
3.) After planting, it is important that the seeds get enough moisture to germinate. Seeding in spring is recommended, however it may be necessary to **provide supplemental irrigation** for the first week or two until the flowers have germinated. Irrigation practices should be determined by the weather, but typically watering twice a day for 15-20 minutes in the early morning and early afternoon, allowing the foliage to dry before nightfall, will keep the soil moist.

Starting over with a new lawn is much more involved, but allows more flexibility in the final lawn plant community. In this case, follow protocols for preparing your site as outlined in the lawn renovation link provided above, including flower species as a part of the seeding mix. Our research on flower establishment in different grasses found that for new plantings, Kentucky bluegrass (*Poa pratensis*) and hard fescue (*Festuca trachyphylla*) allowed the best establishment of Kura clover (*Trifolium ambiguum*)**.** In our trial we used kura clover as a model species because it is slow to establish, making it similar to establishing native flowers.

As an example, we used 'Beacon' hard fescue in our trials to establish a large flowering lawn composed of a number of flowering species. We broadcast seeded grass seed at a rate of 4 lb/1000 ft^2 in late fall (mid November) in what is known as a dormant seeding. We then seeded individual flower species over the hard fescue seed at a rate of about 39 seeds/ft^2. After all seed was applied, we laid germination mats over our planting to protect the seed from extreme rain events that could wash away the seeding. Our trials established naturally without need of supplemental irrigation, as the cool wet spring provided ideal germination conditions. However, if rainfall is not sufficient, irrigation should be provided until the plants have germinated in the spring.

To see a Flowering Bee Lawn, the Minnesota Landscape Arboretum has a

public demonstration site that can be visited any time the Arboretum is open. More information on how the Arboretum planted their demonstration site is [available here.]

Enhancing with Native Flowers

What we know

Native flowers are very important to native bees, especially those that specialize on a small group of related plants. Through our trials at the University of Minnesota, we have learned that the best native plants for lawns share some common traits. They tend to have high germination rates, grow quickly, and are adapted to the soil in which they are sown. Low growth stature to avoid mowing is helpful, but is not a prerequisite if the plant grows quickly. Here are some native species that seem to have potential from our trials.

Ground plum (*Astragalus crassicaprus*)

Ground plum is a low growing species in the pea family. It is native and common to the prairies of Minnesota where soils are well drained. Ground plum has a higher germination rate than many native plants, but is still low compared to cultivated plants. This slow growth rate makes it a better candidate for new lawn planting sites that are well drained. The early bloom of ground plum happens before mowing season is in full swing, and the flowers are visited by long tongued bees such as bumble bees and mason bees.

Lanceleaf coreopsis (*Coreopsis lanceolata*)

Lanceleaf coreopsis is a late spring bloomer in the aster family. Its size can vary dramatically, but typically ranges from between 0.5-2 ft. tall. The vegetative parts of the plant will survive mowing as low as 3 in., but the flowering portions typically shoot above this height. This plant could have potential in lawns, but special mowing practices may need to be observed during bloom as well as some tolerance for their unique appearance. The blooms of lanceleaf coreopsis are attractive to many short and long tongued bees. This plant is highly visited by long-horned bees (*Melissodes*) for pollen.

Lanceleaf self-heal *(Prunella vulgaris* ssp. *lanceolata)*

Self-heal is a member of the mint family, and is distributed widely in the US and Europe. There are three self-heal subspecies, with ssp. *vulgaris* being native to Europe, and ssp. *lanceolata* being native to Minnesota and the U.S. This species prefers rich soils with plenty of water and its quick germination and low growth habit make it ideal for overseeding into mature lawns or as a component of a new lawn planting. We found flowers of self-heal to be negatively impacted by mowing heights of 2.5 in., so we recommend at least a 3.5 in. mowing height. The bloom lasts 2-3 weeks in early to midsummer.

Common bee pollinators visiting flowers on the observation plots in Minnesota include bumble bees, sweat bees, and miner bees.

Calico aster (*Symphyotrichum lateriflorum*)

Calico aster is a late blooming flower in the aster family that typically grows around 3 ft. tall. However when mowed, calico aster will form small dense rosettes and will bloom below a 3.5 in. cutting height. A high germination rate and rapid growth make it a prime candidate for future lawn trials, and for people to experiment with in their own lawns. The flowers of calico aster attract short tongued bees such as sweat bees, and the pollen is also useful to many bees that specialize on flowers in the aster family.

Challenges for Flowering Lawns

One of the inherent challenges of working with native plants is that they are not domesticated, and do not respond to cultivation the same way domesticated species do. A primary example of this is that germination of native plant species can be very low. Seeds often need a special signal that the time is right to germinate. For example, native plant seeds often need a cold stratification period (like winter) before they will break dormancy. All these conditions make native plants more challenging to work with.

Another major challenge of establishing flowering lawns with native plants is the availability of seed. Many promising species are not actively cultivated by local seed producers, and thus are not viable options for trials at this time. Many species are only available in root-stock that is directly buried in the soil, a much more expensive planting method. Interest in providing pollinator foraging resources in lawns will hopefully encourage seed producers to identify and test plant material for larger scale production.

Enhancing with Non-Invasive, Non-Native Flowers

What we know

While non-native plants have some downsides, they can still be very useful in flowering lawns. Lawns by their very nature are challenging environments, but many non-native flowers are ideally suited to lawns. For our research we avoided all of the most common lawn weeds and focused primarily on two species.

Dutch white clover (*Trifolium repens*)

White clover is a ubiquitous lawn flower in the pea family found throughout North America. It is originally from Europe, and was probably introduced by some of the first American settlers. White clover is widely cultivated for grazing pasture due to its high leaf nitrogen. The flowers of white clover are also highly attractive to a number of bee species, with an especially high value to bumble bees and honey bees. White clover thrives in lawns and other areas under cutting management, and used to be a standard components of

lawn seed mixes. A high germination rate, rapid growth, and tolerance for a broad range of conditions make this species ideal for overseeding into lawns or in new lawn plantings.

Creeping Thyme (*Thymus serpyllum*)

Creeping thyme is a flower in the mint family from Europe that is cultivated as an ornamental in the Unites States. As its name suggests, it has a spicy herbal aroma like the culinary herb. Similar to its culinary cousin, this species has a slow and prostrate growing habit that makes it uniquely suited to lawns. Due to a high germination rate, overseeding into established lawns and new lawn plantings is possible, but its slow growth habit greatly reduces the time to full establishment; in fact, it may not establish for several years. Creeping thyme is best suited to sites that are well drained, and blooms best with mowing heights above 3.5 in.

What we need to know/ challenges

There are many species of non-native flowers that are, for better or worse, in our lawns for the long haul. Some of these species are relatively well behaved outside of lawns, but many can become invasive in other areas. When considering non-native plants for flowering lawns, it is important to have a good sense of how aggressive they can be outside of their desired location and if they have any value to bees. Unfortunately that is no easy task. Some non-native species that have value for bees, such as Siberian squill (*Scilla siberica*) and bugle weed (*Ajuga reptans*), are aggressive and rapidly spread outside of their planting area. Others such as sweet alyssum (*Lobularia maritima*) and English lawn daisy (*Bellis perennis*) may stay constrained to lawns, but have questionable value to wildlife and are not reliably winter hardy in central Minnesota.

Management of a Flowering Lawn

Once flowers are established in the lawn, managing flowers or other weeds that are not desirable can be a challenge. Hand weeding will always be the preferred option for weed control in a flowering lawn, although this can be quite labor intensive. Spot treating weeds with selective herbicides can limit plants that are not wanted. Using a broadcast broadleaf herbicide will kill most flowers that you have planted. The exception is Dutch white clover, which is fairly resistant to one common herbicide, 2,4-D. Iron chelate products can also be used to spot-treat broadleaf weeds as they establish and this is an organic option for weed control. Synthetic and organic preemergence herbicides applied in the spring can help to prevent the germination of summer annual weedy grasses, like crabgrass and foxtail. Corn gluten meal, which acts as both a preemergent herbicide and a fertilizer, is an organic option that will work once all grasses and flowers are established in lawns. Some synthetic preemergent products could be damaging to flowers, so be sure to read the label and follow all application directions.

Mowing the flowering lawn to a height of between 3.5 and 4 in. will ensure that flowering plants survive and produce flowers to sustain pollinators. Higher mowing heights will also reduce the required mowing frequency and will enable the grasses and flowering plants to have a deeper, more robust root system improving the quality and stress tolerance of the lawn. The one third rule is a good guide to help determine mowing frequency: do not cut off more than one third of the vegetation at one time. If the desired mowing height is 4 in., then the lawn

should be mowed when it reaches 6 in., cutting off 2 in. or one third. Be sure to maintain sharp mower blades to reduce mowing stress. Returning clippings when mowing will also help to add nutrients back to the soil.

Soil moisture status should be monitored and replenished through irrigation during extended drought periods and this will change based on the season and year. In an average year, irrigation requirements will be minimal, with lawns requiring from 0-3 irrigation events over the course of a growing season from May to October. Generally speaking, 2-3 in. of precipitation per month should be enough to sustain the quality of a flowering lawn, assuming the precipitation does not occur all at once. In dry years, irrigation requirements will be greater. If no precipitation occurs over a 2-week period, consider irrigating with 0.5 to 1 in. of water. This can be accomplished with an in-ground irrigation system, portable sprinklers or by hand watering.

Fertilizer requirements will be minimal if clippings are returned, mowing heights are kept high, and the soil quality is good. Soils with greater levels of organic matter (> 5% by weight) will hold more nutrients and moisture. Organic matter can be determined from a soil test. See http://soiltest.cfans.umn.edu. If organic matter is less than 5%, consider incorporating high quality compost or peat into the lawn during the renovation process. This can be accomplished through tillage, if conducting a complete renovation, or through aerating, topdressing lightly with the chosen material and working it into the aeration holes. For lawns with low density and vigor, consider making one fertilizer application in the fall around Labor Day. This application should generally supply 1 pound of nitrogen and 0.5 pounds of potassium per 1000 ft^2. For example, a 20-0-10 fertilizer contains 20% nitrogen, 0% phosphorus, and 10% potassium. Applying this fertilizer at a rate of 5 pounds per 1000 ft^2 will achieve the desired nitrogen and potassium rates. Be sure to select a fertilizer that has at least 30% of the nitrogen in the slow release form; 30% of 20 = 6% of the nitrogen in this fertilizer example should be slow release. This will help to reduce environmental loss of nitrogen and provide long-term nutrition. Organic fertilizers are also a good option and will contain slow release nitrogen. Any more fertilizer than recommended will most likely encourage grass over flowers. For additional nutrients, such as phosphorus, consider having your soil tested.

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

Funding for this project was provided by
the Minnesota Environment and Natural Resources Trust Fund
as recommended by
the Legislative-Citizen Commission on Minnesota Resources (LCCMR)

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