M.L. 2016, Chp. 186, Sec. 2, Subd. 08a as extended by M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 19 as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2
Project Abstract
For the Period Ending June 30, 2021

PROJECT TITLE: Bee Pollinator Habitat Enhancement – Phase II
Project Manager: Marla Spivak
Organization: University of Minnesota
Mailing Address: 1980 Folwell Ave; 219 Hodson Hall
City/State/Zip Code: St Paul, MN 55108
Telephone Number: (612) 624-4798
Email Address: spiva001@umn.edu
Web Address: www.BeeLab.umn.edu
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2016, Chp. 186, Sec. 2, Subd. 08a as extended by M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 19 as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2

APPROPRIATION AMOUNT: $387,000
AMOUNT SPENT: $381,931
AMOUNT REMAINING: $5,069

Sound bite of Project Outcomes and Results
Florally enhanced fine fescue lawns provide forage for diverse bee pollinators, maintain recreational and aesthetic value, and reduce the need for irrigation, pesticides, fertilizers, and mowing. In response to demand, many local retailers now sell bee lawn seed mixes, a trend that will likely grow in Minnesota and nationally.

Overall Project Outcome and Results
Our research demonstrates how small changes to a landscape can have meaningful conservation impacts on pollinators. Within Minneapolis parks, florally enhanced lawns (containing Dutch white clover, self-heal, and creeping thyme) had more diverse and distinct bee communities than lawns containing just Dutch white clover. Fifty-five species of wild bees were found foraging on Dutch white clover, and the vast majority were native species; however, *Apis mellifera*, the European honey bee, was the most common species. Seven bee species were found only on self-heal and not observed on Dutch white clover. The addition of flowers allows lawns to maintain their recreational and aesthetic value while still providing high-quality forage for pollinators. Park visitors supported bee lawns (95%) for their aesthetics and bee conservation, and city land managers emphasized need for education on the multiple benefits of bee lawns. Flowering lawns are highly sustainable, utilizing low-input fine fescues that reduce the need for irrigation, fertilizer applications, and mowing. Bee lawns encourage residents to view lawn flowers as food for bees rather than as a nuisance, reducing the perceived need to apply herbicides to the landscape. In addition, Bee lawns have become increasingly popular throughout the state of Minnesota as a result of this work; many local home and garden retailers in Minnesota now sell bee lawn mixes, which include both flower seeds and fine fescues. The Lawns to Legumes (L2L) program strives to make pollinator friendly lawns a trend nationwide. A newly funded grant will support bee lawn research integrated with other urban ecosystems questions: *National Science Foundation: The Changing Nature of Cities: Ecological and Social Dynamics in the Minneapolis-St. Paul Urban Ecosystem.* We see this as an excellent extension and expansion of the LCCMR project that will build future collaborations with Minnesota State agencies, Twin Cities municipalities, non-government organizations and businesses.

Project Results Use and Dissemination

There has been an amazing amount of interest by the general public about bee lawns. We have published four peer-reviewed research articles, have given dozens of talks, workshops, podcasts, field days, classroom lectures, and scientific conference presentations on bee lawns. Bee lawn materials are accessible on three different UMN websites geared toward different audiences (the general public on the UMN Extension site which gets hundreds of thousands of visits every year, turfgrass audiences on the Turfgrass Science website and entomology audiences on the Bee Lab website). Our continued outreach on bee lawns will reach many thousands of Minnesotans.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2016 Final Report

Date of Report: October 13, 2021

Final Report

Date of Work Plan Approval: June 7, 2016

Project Completion Date: June 30, 2021

PROJECT TITLE: Bee Pollinator Habitat Enhancement – Phase II

Project Manager: Marla Spivak

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Telephone Number: (612) 624-4798

Email Address: spiva001@umn.edu

Web Address: www.BeeLab.umn.edu

Location: Statewide

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$387,000**
	Amount Spent:	**$381,931**
	Balance:	**$5,069**

Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 08a as extended by M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 19 as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2

Appropriation Language:
$387,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to continue assessment of the potential to supplement traditional turf grass by providing critical floral plant resources to enhance bee pollinator habitat. Plant materials and seeds must follow the Board of Water and Soil Resources' native vegetation establishment and enhancement guidelines. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

ML2019 - Carryforward; Extension (a) The availability of the appropriations for the following projects is extended to June 30, 2020: (11) Laws 2016, chapter 186, section 2, subdivision 8, paragraph (a), Bee Pollinator Habitat Enhancement - Phase II;

M.L. 2020 - Sec. 2. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2021]

I. PROJECT TITLE: Bee Pollinator Habitat Enhancement - Phase 2

II. PROJECT STATEMENT:

Why: We received funding in 2013 to develop an innovative way of helping pollinators by florally enhancing turf areas that are not heavily used for human recreation. We identified some promising native floral species that withstand mowing pressure and continue to flower when seeded into lawn areas. The native flowers include: self-heal (*Prunella vulgaris* var. *lanceolata*), ground plum (*Astragalus crassicarpus*), calico aster (*Symphyotrichum lateriflorum*), and lanceleaf coreopsis (*Coreopsis lanceolata*). Seeds for these plants are available locally from native seed vendors except *Prunella vulgaris* var. *lanceolata*. We consulted with Dan Shaw at the Board of Water and Soil Resources (BWSR) about the use of this ecotype, any potential problems or risks with it use, and where we could obtain local seed (see attached letter from BWSR). Dan Shaw contacted local native plant nurseries (Prairie Moon, Shooting Star Native Seeds, Prairie Meadows, Prairie Restorations, Minnesota Native Landscapes) and none of them sell the local ecotype. Several of the nurseries said they will begin collecting seed and welcome the opportunity to harvest and market this ecotype to fulfill the large public demand for flowering lawns in Minnesota (see Activity 1 for more information). Thus, we are working with native seed growers and BWSR to develop local seed sources for this plant, and to increase availability of seed for the other species for future studies and for use by the public. As native species take several years to establish, we are requesting Phase 2 funding to test new native flowering species, and to verify that the flowering lawn options we have developed enhance bee visitation while maintaining the function and aesthetics of mowed and manicured turf. While we will continue to showcase the bee lawns in public demonstration areas, it also is important to understand citizen's concerns about pollinators and flowering lawns as well as their ideas for how these lawns could be used to benefit their families, businesses, and communities. In this way, public land managers can be informed about the most effective and efficient ways to implement flowering lawns.

Goal: Our goal is to provide a concrete way to support the nutritional needs of all bees. Bee pollinators, including honey bees and some of the 400 species of bees native to Minnesota, are in decline 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). Minnesota is leading the nation in legislative initiatives to help pollinators, and as a result, public awareness about the plight of pollinators is at an all time high. People are hungry for action-steps they can take to help.

Outcomes: The addition of native flowers into turf will provide nutritional resources for pollinators, and will reduce intensive inputs of water, fertilizers and pesticides. Flowering lawns could provide a natural buffer to water resources in areas where low-growing, more manicured looking lawns are preferred. Flowering lawns would beautify Minnesota, protect our natural resources, and help achieve important state and federal pollinator protection initiatives.

How: We propose 2 activities: 1) Quantify bee abundance and diversity, and floral blooms on lawns in four Minneapolis parks enhanced with native flowers compared to existing lawns in four paired parks containing only white clover; 2) Continue outreach activities through public demonstration plots, and evaluate key concerns and new ideas public and private landowners and landscape maintenance personnel have about using flowering lawns. Due to their location, our 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.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of October 2016:

Activity 1. This summer, new graduate student James Wolfin obtained baseline information on the bee communities that visit *Trifolium* repens (white clover) already present in Minneapolis park turf. He sampled bees in 12 Minneapolis parks, each paired by region: Audubon and Windom (northeast Minneapolis); Willard and North Commons (north Minneapolis); Kenwood and Painter, (southwest Minneapolis); and Matthews and Longfellow (south Minneapolis). The bees are being curated and identified currently. This November, we will florally enhance turf by seeding flowers into 800m^2 area (40m^2x20m^2) plots within four of these parks (one per pair). Each of the enhanced plots will already contain white clover, and we will add flowers in addition to the clover. This will allow us to compare bee visitation on white clover in one of the paired parks to the clover-plus-

flowers at the other paired park in each region in subsequent years. We will first scalp (mow to less than 1 inch) and aerate the plots, then seed with a mixture of *Prunella vulgaris* (self-heal)*, Coreopsis lanceolata (*lanceleaf coreopsis)*, Symphyotrichum lateriflorum* (calico aster) and non-native, non-invasive *Thymus serpyllum* (creeping thyme). Seed was purchased from local nurseries to ensure that local ecotypes of each species were being used (with exception of *Thymus*).

Activity 2. Since Summer 2016, K. Nelson (Co-PI) and new graduate student Hannah Ramer conducted cross-team training on pollinators and bee lawns, visited park site, met with Minneapolis Parks and Recreation Board (MPRB) planners, and initiated design of a pilot interview/survey guide.

Project Status as of April 2017:

Activity 1. In November 2016, plots within four Minneapolis parks -- Audubon park (NE), Matthews Park (SE), Kenwood park (SW), and Willard park (NW) -- were florally enhanced though the process or dormant seeding. Five forbs were seeded into the existing turf: self-heal (*Prunella vulgaris ssp. lanceolata),* calico aster (*Synphyotrichyn lateriflorum)*, lanceleaf coreopsis (*Coreopsis lanceolate),* Dutch white clover (*Trifolium repens)*, and creeping thyme *(Thymus serpyllum)*. The seeded areas in each park were placed in low traffic areas to not disrupt normal park activities. Signage was placed in the center of each lawn to raise awareness about the project, and to reduce foot traffic during establishment. This summer, the number and diversity of bees on flowers in the four enhanced park will be surveyed, and compared to the number and diversity bees on flowers in four paired parks that were not florally enhanced.

Activity 2. Hannah Ramer and Kristen Nelson developed a survey methodology to better understand park visitors' perceptions and concerns about enhanced flowering lawns. This survey will help to inform our future efforts to examine the perceptions and concerns of adjacent land owners and public park land managers.

Dissemination. Work from this project was presented at the 2017 American Bee Research conference, the Minnesota Turf and Grounds Field Day, the Northern Green Expo in Minneapolis, and at several master gardener and beekeeper associations. This project is featured as an alternative option to traditional turfgrass management practices in the "Resilient Yards Workshop", a twelve part workshop for Minneapolis homeowners.

Project Status as of October 2017:

Activity 1. Bee communities were sampled weekly in the 800 m^2 plots within 8 parks that were either enhanced (n=4) or unenhanced (n=4), as well as 8 additional Minneapolis parks. Additionally, the number of blooms was recorded at each site. At total of 2013 bee specimens were collected, including 40 unique species. Data on diversity and relative abundance of bee species at enhanced and unenhanced parks is being analyzed. Due to low bloom in enhanced plots, new plug plants of self-heal (*Prunella vulgaris),* creeping thyme (*Thymus serpyllum)*, lanceleaf coreopsis (*Coreopsis lanceolate)*, and calico aster (*Symphiotrichum lateriflorum)* were purchased and 32 plants of each species were established within the 4 enhanced plots in late summer. The methods used to collect data for bee abundance and diversity will be repeated in the spring of 2018.

Activity 2. The survey team conducted 149 hours of in-person surveying in the four study parks with enhanced flowering lawns, between May 30-August 25. All park visitors who were over 18 years old and proficient in English were invited to participate (though we did not interrupt active sports or play to recruit participants). We obtained a total of 538 completed surveys, which represents a 57% response rate. At this point the park user sampling is complete. Analysis of survey data is in progress and will be used to inform the Minneapolis Park and Recreation Board (MPRB) staff about park user knowledge of and attitudes about flowering lawns, pollinators, and the relationship with park uses. We will develop publications and presentations based on the 2017 survey, and design the 2018 survey for public land managers who attend the demonstration workshops in the summer of 2018.

Dissemination: The work from this project was presented at 8 different research and outreach events between April and October, including the Minnesota Nursery and Landscape Association, Minnesota Turf and Grounds Foundation Professional Lawn Care Workshop, Minnesota State Fair at the Agriculture Horticulture Building, the City Parks Alliance Greater and Greener Conference (an international conference for public parks), and the Minnesota State Extension Master Gardener Conference. The popular Bee Lawn brochure, created as a

collaborative effort between the Bee Lab, Turfgrass Science Lab, and the Minnesota Landscape Arboretum was updated and reprinted.

Project Status as of April 2018:

Activity 1. We have identified 40 species of bees foraging on white clover, *Trifolium* repens, in Minneapolis parks. The majority of bees (56%) were native bees, and 44% were honey bees, indicating that this flower species is an important food source for diverse bees in urban areas. This summer, 2018, we anticipate that the flowers planted within the enhanced plots at four parks will bloom, leading to greater floral diversity and thus greater bee diversity, compared to the clover-only plots.

Activity 2. We completed an analysis of the park user survey data and developed three products that can be used to inform the Minneapolis Park and Recreation Board (MPRB) staff and broader audiences about park user knowledge of and attitudes about flowering lawns, pollinators, and the relationship with park uses (listed under Activity 2 update). Survey results indicate the public is highly supportive of flowering lawns in Minneapolis parks.

Dissemination: The work form this project was presented at 16 different research and outreach events, listed below.

Project Status as of October 2018:

Activity 1. During the 2018 field season, 43 unique species of bees were found foraging on *Trifolium repens*, *Thymus serpyllum,* and native *Prunella vulgaris.* Eight bee species were unique to enhancement flora, and were not observed on Dutch white clover. The most common bee species on Dutch white clover was *Andrena wilkella,* on self-heal was *Lasioglossum anomalum*, and on creeping thyme was *Augochlorella aurata*; all three are native bee species. Preliminary results quantifying bee diversity at enhanced and untreated parks, using Shannon diversity indices (alpha diversity), suggested that local bee diversity was greater at enhanced parks. Beta diversity measures and NMDS plots will be used to compare bee communities between enhanced and untreated parks.

Activity 2. Six focus group interviews were conducted with public land managers from across the Minneapolis-St. Paul Metropolitan Area, to elicit information about perceived benefits of and barriers to adopting flowering bee lawns on public parkland e. Participants included 52 public land managers, representing 27 cities and counties. Information from focus groups will be used to shape outreach and education efforts in the future. The focus groups from Activity 2 served as outreach opportunities, including a general overview of flowering lawns as well as more technical information about seeding protocol.

Dissemination: Hannah Ramer (PhD student) and Dr. K Nelson completed a manuscript describing the findings from the 2017 park visitor survey from Activity 2. The paper was submitted to *Landscape and Urban Planning* in July 2018 and is currently under review. James Wolfin (Master's student) and H. Ramer published an Extension article in *Hole Notes* on how to support pollinators in golf courses. Findings from Activities 1 and 2 were presented at three conferences, a workshop and field day, and were featured in three press/ radio releases.

Amendment Request (11/02/2018)

Explanation and Rationale: We requested a legislative extension on this project on October 31, 1018. We request the extension because we need another full summer and fall to complete the education and outreach objectives in Activity 2. We are not making changes to proposed Activities; only the timeline for Activity 2. There has been considerable interest in flowering lawns by municipal land managers and the public in general. We conducted six focus groups with public land managers from over 100 cities and county park-systems to gather data on their perceptions of flowering bee lawns. To accommodate this unexpected level of interest and their preference for not meeting in the summer months, we held the focus groups this fall 2018, which set back our projected timeline for data analysis. We plan to have a major demonstration event in July and August 2019, when the flowering lawns are in full bloom. By that time, data analysis from Activity 1 on the diversity of bee species that visit the flowers will be complete and we can include the data in our outreach materials for the demonstrations. The extend time will help the graduate student assigned to this event sufficient time to develop

outreach materials for the event. In addition, these materials will be shared with Minnesota municipalities and counties to modify for their own use in local 'bee lawn' demonstrations and outreach events.
Budget Shifts: Activity 1: Equipment reduced to $1789 (reduced $611), and Travel increased to $9059 (increased $59). Activity 2: Personnel increased to $158,942 (increased $4665), Other (survey research) reduced to $3302 (reduced $4113)

Amendment Request signed into law 5/31/19.

Project Status as of April 2019:

Activity 1: We conducted 280 site visits to Minneapolis parks from 2016 - 2018 and observed a total of 62 unique bee species. On lawns with only Dutch white clover, we identified 56 unique bee species, the majority of which were native bees. We compared bee diversity on clover-only lawns and lawns that we enhanced with a seed mix containing Dutch white clover, self-heal, and creeping thyme. Over three years, we observed higher bee diversity at enhanced parks compared to clover-only parks, and enhanced parks supported different communities of bees than clover-only parks. These results provide evidence of the benefit to native bees by enhancing parks with additional species beyond Dutch white clover.

Activity 2. We shared our findings on public perceptions of bee lawns from the 2017 park visitor survey: *Exploring park visitor perceptions of 'flowering bee lawns' in neighborhood parks in Minneapolis, MN, U.S.*, and a peer reviewed article (Ramer et al. in press) was accepted for publication in *Landscape and Urban Planning*. We also examined the perceptions that public land managers have of flowering bee lawns through six focus group interviews with public land managers from across the Minneapolis-St. Paul Metropolitan Area. Fifty-two public land managers, representing 27 cities and counties, participated. We are planning the 2019 summer activities for a major field-day event for metropolitan land managers hosted by Minneapolis Park and Recreation Board collaborators. Finally, we began drafting materials for a *bee lawn toolkit* to assist Minnesota public land managers step through the decision-tree analysis necessary for planning, implementation, maintenance, and public outreach.

Dissemination: Results of this work were accepted for publication in two peer-reviewed manuscripts on Bee Lawns (one from Phase 1 of this project), presented at three professional conferences, delivered at five workshops, and presented as a lecture in a Turf Management course at the University of Minnesota.

Project Status as of November 2019:

The work we have done has been well timed in that recommendation from our work can be used to enhance the success of the **Lawns to Legume** program currently being implemented in Minnesota. This legislatively-mandated program will allow Minnesota residents to use the knowledge we have gained in this project for the benefit of pollinators. Bee Lawns were highlighted by a number of local (MN Daily), state (e.g, Star Tribune, CBS Minnesota) and national news outlets (e.g., Smithsonian.com; US News and World Report).

Activity 1. James Wolfin will graduate with a Master's degree in Entomology in December 2019, and will be publishing his findings on bee diversity and abundance on flowering bee lawns. He is currently working at Metro Blooms to install 14 boulevard bee lawns across North Minneapolis as part of an environmental justice project in collaboration with the city of Minneapolis. A peer reviewed article was published in *Horticultural Science "*Flowering Lawns: How turfgrass species and seeding rate affect establishment and bloom of a model forb, *Trifolium ambiguum"*

Activity 2. We organized the Flowering Bee Lawn Event with the other team members, Audubon Park, Minneapolis, Public Land Manager talks and demonstrations in partnership with the Minneapolis Park and Recreation Board. We developed six signs for outreach about bee lawns, developed for municipalities and others to modify for their own municipal residents and programs. Hannah Ramer (PhD student) lead the production of a Land Manager Toolkit. *Ramer, H., Wolfin, J.E., Nelson, K.C., Spivak, M., Watkins, E., Nelson, K.C., Pulscher, M*. 2019. Flowering Bee Lawns: A Toolkit for Land Managers. The bee lawn toolkit can assist Minnesota public land managers, from beginners to those with established areas, step through the decision-tree analysis necessary for planning, implementation, maintenance, and public outreach. Hannah Ramer, et al. have

completed a first journal manuscript draft, currently titled, *"Using Ostrom's 'rules-in-use' to understand public land managers' perceptions of flowering bee lawns on parklands*".

Project Status as of April 2020:

Activity 1. Our research demonstrates how small changes to a landscape can have meaningful conservation impacts on pollinators. In our surveys of bees on florally enhanced lawns within Minneapolis parks, blooming flowers accounted for ~7% of the landscape, with turfgrass still serving as the predominant species. The addition of flowers allows lawns to maintain their recreational and aesthetic value while still providing high quality forage for pollinators. Furthermore, flowering lawns are highly sustainable, utilizing low-input fine fescue that reduces the need for applications of irrigation, fertilizer, and mowing. Bee lawns encourage residents to view lawn flowers as food for bees rather than as a nuisance, reducing the perceived need to apply herbicides to the landscape.

Activity 2. Hannah Ramer (lead) and Kristen Nelson drafted, submitted, and revised a manuscript based on the land manager focus group data, titled *Applying 'action situation' concepts to public land manager's perceptions of flowering bee lawns in urban parks* for publication in *Urban Forestry and Urban Greening*. The article was recently accepted for publication in 2020. In addition, we responded to multiple media requests for comments and interviews associated with bee lawns, park user perceptions of bee lawns, and the benefits of bee lawns.

Bee lawns have become increasingly popular throughout the state of Minnesota as a result of this work. Many local plant retailers across the state of Minnesota have started to carry bee lawn mixes, flower seeds, and fine fescue grass. The Lawns to Legumes (L2L) program hopes to make pollinator friendly lawns a trend nationwide. Recently, the L2L team was invited to present information about L2L alongside state legislator Rick Hansen to the National Caucus of Environmental Legislators in an effort to promote pollinator friendly turf alternatives across the nation. We believe that the research conducted through this funding will inspire change nationwide.

In the next phase, we will contact all the land manager participants in field days and focus groups to identify where they have installed the bee lawns or plan to install bee lawns this coming summer. We will map these sites and any other bee lawn sites they are aware of in their communities. Landscaping companies have been promoting bee lawns as one of their offerings and we plan to identify the sites, both residential and public, that they installed. In late July and August, if travel conditions allow, we will visit all the sites to evaluate the vegetation and if possible, sample bees. Finally, in the fall we will conduct brief interviews with the municipal land managers and other landowners about their experience with bee lawns and plans for the future.

Project extended to June 30, 2021 by LCCMR 6/18/20 as a result of M.L. 2020, First Special Session, Chp. 4, Sec. 2, legislative extension criteria being met.

Project Status as of October 2020:

As a result of the research conducted through Activity 1, and through the efforts of the Lawns to Legumes program (funded by ENRTF), bee lawns are becoming increasingly popular in Minnesota. Local nurseries have noted record sales for bee lawn seed this year. Of 187 participants in the Lawn to Legume program in 2020, 35 report that they have planted bee lawns that total 130,000 square feet (data from Dan Shaw, BWSR). We will continue to gather more statistics on the number of homeowners that have installed bee lawns as part the Lawn to Legume legislative initiative.

We conducted informal interviews with Minneapolis-St. Paul metro area public land managers and when possible, due to COVID, site visits of municipal pollinator and bee lawn exhibits and plantings to map exiting bee lawns, gather information on establishment and maintenance, and identify communities with future plans for bee lawns. Plans for 2021 are to use these findings to inform future research by the bee lawn team and in our respective National Science Foundation or USDA NIFA research projects. In addition, we will develop new outreach materials based on the interview findings.

Project Status as of April 2021:

We continue to develop outreach materials that communicate how to establish a bee lawn and the benefits that these landscapes can provides for pollinators in Minnesota. Kristen C. Nelson and Eric Watkins are part of a team that received funding from the National Science Foundation to support bee lawn and garden research integrated with other urban ecosystems questions over the next six years, and likely beyond. This new research will provide an excellent extension and expansion of the LCCMR project that will build future collaborations with Minnesota State agencies, Twin Cities municipalities, non-government organizations and businesses.

Overall Project Outcomes and Results:

Our research demonstrates how small changes to a landscape can have meaningful conservation impacts on pollinators. Within Minneapolis parks, florally enhanced lawns (containing Dutch white clover, self-heal, and creeping thyme) had more diverse and distinct bee communities than lawns containing just Dutch white clover. Fifty-five species of wild bees were found foraging on Dutch white clover, and the vast majority were native species; however, *Apis mellifera*, the European honey bee, was the most common species. Seven bee species were found only on self-heal and not observed on Dutch white clover. The addition of flowers allows lawns to maintain their recreational and aesthetic value while still providing high-quality forage for pollinators. Park visitors supported bee lawns (95%) for their aesthetics and bee conservation, and city land managers emphasized need for education on the multiple benefits of bee lawns. Flowering lawns are highly sustainable, utilizing low-input fine fescues that reduce the need for irrigation, fertilizer applications, and mowing. Bee lawns encourage residents to view lawn flowers as food for bees rather than as a nuisance, reducing the perceived need to apply herbicides to the landscape. In addition, Bee lawns have become increasingly popular throughout the state of Minnesota as a result of this work; many local home and garden retailers in Minnesota now sell bee lawn mixes, which include both flower seeds and fine fescues. The Lawns to Legumes (L2L) program strives to make pollinator friendly lawns a trend nationwide. A newly funded grant will support bee lawn research integrated with other urban ecosystems questions: *National Science Foundation: The Changing Nature of Cities: Ecological and Social Dynamics in the Minneapolis-St. Paul Urban Ecosystem.* We see this as an excellent extension and expansion of the LCCMR project that will build future collaborations with Minnesota State agencies, Twin Cities municipalities, non-government organizations and businesses.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Floral enhancement of urban lawns and pollinator community response
Description:

In Phase 1 of this project, we found that *Festuca brevilipa* (hard fescue) and *Poa pratensis* (Kentucky bluegrass) allow a significantly higher establishment of flowering plants compared to other grass species. For established turf lawns that are well managed (highly fertilized and controlled for broadleaf weeds), we found the best way to establish native flowers was to seed them after scalping (mowing to a very low height of cut) of the lawn. In established turf that is not well managed, no scalping was needed; the native flowers established after direct seeding. *Prunella vulgaris* (self-heal) establishes particularly well in moist fertile sites even after regular mowing to 3.5 inches. The native forb *Astragulus crassicarpus* (ground plum) establishes better in sandy soils and low fertility sites after mowing. Among other native plants we tested —*Menthe arvensis, Coreopsis lanceolata, Monarda punctate, Astragalus canadensis,* and *Symphyotrichum lateriflorum*— two species, *Symphyotrichum lateriflorum* and *Coreopsis lanceolata,* seem to withstand mowing and hold the most promise for our future trials in Phase 2.

While we will continue testing the establishment of these and additional native flowering species in lawns, it is important to verify that the flowering turf options we are developing actually enhance bee visitation while maintaining the function and aesthetics of mowed and manicured turf. To measure the effectiveness of flowering lawns to provide floral nutritional resources for bees, we will compare bee visitation on lawns enhanced with native floral species to bee visitation of lawns containing only white clover, *Trifolium repens*. In

collaboration with the Minneapolis Park and Recreation Board we have identified 8 parks in the city of Minneapolis for our bee visitation trials (these park lawns are primarily comprised of Kentucky bluegrass). In 4 of the 8 parks, we will enhance one large turf area (approximately 400 m^2 in each park) with a mixture of native flowers. In the other 4 parks, chosen by proximity and similarity in type of public use, same size plots will be delineated that already contain white clover (but no other flowering species). We will pair these parks based on proximity to allow comparisons between parks with and without enhanced floral resources. The paired parks we are considering include:

1. Audubon and Windom (northeast Minneapolis)
2. Willard and Hall (north Minneapolis)
3. Kenwood and Painter, (southwest Minneapolis)
4. Matthews and Longfellow (south Minneapolis)

We will establish native flower mixture lawns using methods developed based on our work in Phase 1 of this overall project. The native flowering plants will be established from seed acquired through partnerships with local seed producers, facilitated and approved by BWSR. Local ecotype seeds from ground plum (*Astragalus crassicarpus*), calico aster (*Symphyotrichum lateriflorum*), and lanceleaf coreopsis (*Coreopsis lanceolata*) are available from local native seed nurseries. Seed from self-heal (*Prunella vulgaris* var. *lanceolata*) is not available locally, but seed producers (e.g., Prairie Moon, Prairie Restorations Inc., Minnesota Native Landscapes) have agreed to harvest some, to be available in 2017. As we plan to begin seeding our small experimental plots in August 2016, Dan Shaw from BWSR, has attached a letter that states:

"It is my recommendation to use the seed source from Oregon in this case, as the species is relatively common across the United States, the study plots are relatively small (around 650 square feet), located in a metropolitan area, and precautions can be put in place to minimize genetic risks to local populations of the species. Results from this study will also help initiate production of local seed sources. If the Oregon source is approved the following precautions should be used to protect local populations

-Planting locations should be a maximum of ¼ miles from known "local" populations.

-Seed heads should be removed each fall followed by disposal of the seed.

-Herbicide treatments or repeated tilling (three times during the growing season) should be conducted over the entire area that was seeded for the study for a minimum of one season following completion of the study."

We will encourage these producers to increase availability of these seeds for sale to the homeowners and businesses interested in establishing flowering lawns in the future (see attached letter from BWSR).

In August 2016, existing lawn areas will be mowed to a short height of cut (0.75 inches). These areas will then be core-aerified, after which seed of native flowering plants will be applied to the area using a drop spreader. Trial areas will then be irrigated as needed during establishment to ensure the development of a successful stand.

We will collect information on the abundance and richness of bees visiting both the enhanced and the unenhanced paired park lawns. Visitation will be quantified by collecting bees directly from blooms along specified transects through the plots. All non-honey bee specimens will be curated and databased in collaboration with Dr. Dan Cariveau and Dr. Ralph Holzenthal in the Entomology department at the University of Minnesota.

We will collect data on plant establishment in our plots throughout the season to better understand how flowering plants establish and recover after mowing in park lawns. We will document plant and floral abundance within one square meter quadrats every 5 meters along both sides of a 30-meter transect in the enhanced parks. This data will inform how well our flowering plants have established, and will be correlated with bee visitations to enhanced plots compared to control plots to show that the enhanced plots do provide nutritional floral resources for bees.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 212,414
Amount Spent: $ 212,414
Balance: $ 0

Outcome	Completion Date
1. Plant native flowering plant species in lawns at four Minneapolis parks.	November, 2016
2. Quantify number and diversity of bee pollinators on turf enhanced with native flowers and compare to unenhanced park turf with common flowering weeds.	May 2019
3. Quantify floral abundance and rate of bloom after mowing	November, 2018

Activity 1 Status as of October 2016:

This summer we obtained baseline information on the bee communities that visit *Trifolium* repens (white clover) already present in Minneapolis park turf. We will use this baseline information to determine if enhancing turf with low growing forbs also will enhance the bee communities that visit them. This summer, new graduate student, James Wolfin, sampled 12 Minneapolis public parks in areas where there was pre-existing white clover. The parks were the ones listed above in our proposal with one exception in North Minneapolis where, in consultation with Mary Lynn Pulscher of the Minneapolis Parks and Recreation Board North Commons, we decided that North Commons was more suitable than Hall for this study. Thus the 8 parks sampled were:

1. Audubon and Windom (northeast Minneapolis)
2. Willard and North Commons (north Minneapolis)
3. Kenwood and Painter, (southwest Minneapolis)
4. Matthews and Longfellow (south Minneapolis)

At each park, a 30 meter transect was walked for a duration of 20 minutes, every 2 weeks, during which all observed bees were collected using a non-destructive bee-vacuum. These bees were curated, and are currently being identified and databased within the Entomology department at the University of Minnesota.

This November 2016, we will enhance 4 of the parks (one from each pair: Audubon, Willard, Kenwood and Matthews), which will allow us to compare bees visiting the paired park with just white clover (e.g., Windom) with the other paired park with clover plus a mixture of other flowers (e.g., Audubon). Each enhanced park will be seeded with a mixture of *Prunella vulgaris* (self-heal)*, Coreopsis lanceolata (*lanceleaf coreopsis)*,* and *Symphyotrichum lateriflorum* (calico aster) and *Thymus serpyllum* (creeping thyme) in an 800m^2 area (40m^2x20m^2) plot (we have not been able to obtain sufficient supplies of *Astragalus crassicarpus* (ground plum); therefore this species will not be included. The selected forbs vary in both bloom size and petal color to attract a wide assortment of bees, as well as phenology to ensure that visiting bees have a consistent food source throughout the foraging season. Seed was purchased from local nurseries to ensure that local ecotypes of each species were being used. Dormant seeding of these flowers will occur in November before the ground freezes to ensure that germination will occur the following spring once the soil warms. Based on our previous research findings, the enhanced plots will be scalped and aerated before seeding to improve establishment rates within the existing turf. Enhanced plots will be located in isolated areas to minimize foot traffic during establishment. A sign designating the area as a "University of Minnesota Research Plot" will accompany each of these plots.

Next summer, the employees of Minneapolis Parks and Recreation staff will mow all eight sites once every two weeks. Next summer, collection of bees at the 8 parks will follow the same protocol used this summer. A thirty meter transect walk will take place every two weeks, with each sampling period lasting a total of twenty minutes. A 1m^2 quadrat will be dropped every five meters on each side of each transect, and the forbs within the quadrat will be recorded. The bee communities observed at enhanced parks and clover-only parks will be compared to determine if forb enhancement had a significant effect on the bee community composition. The bee communities observed at the enhanced parks will likely shift over time, due to the establishment rate of the floral species. While *Prunella* (self-heal) is expected to germinate and bloom in spring

2017, the other forbs may not bloom until subsequent years, thus altering the bee communities observed over time.

Activity 1 Status as of April 2017:

On November 22, 2016 four "enhanced" parks were established via dormant seeding. Audubon park (NE), Matthews Park (SE), Kenwood park (SW), and Willard park (NW) were designated as sites to be enhance with flowers. Dormant seeding is the process of putting down seed while the ground is not yet frozen, but cold enough so seed germination will not occur until the following spring when the soil begins to warm. Five forbs were selected in total for establishment into these enhanced parks. Dutch white clover (*Trifolium repens)*, self-heal (*Prunella vulgaris ssp. lanceolata),* and creeping thyme *(Thymus serpyllum)* were selected based on the establishment rates observed in Phase One of this project, and the high quality forage they provide to bee pollinators. Calico aster (*Synphyotrichyn lateriflorum)* and lanceleaf coreopsis (*Coreopsis lanceolate)* have been added to the seeding mix as well to increase the presence of native flowers within bee lawns, and because of their ability to attract native bee pollinators.

In each park, a 40 m x 20 m (800 m^2) section was designated as a bee lawn habitat enhancement area. These areas were selectively placed in low traffic areas of the park, as not to disrupt normal park activities, and to reduce the potential for wear on bee lawns during establishment. Before seeding, each enhanced park was scalped and aerified. Scalping, mowing the turfgrass below one inch, is done to improve seed to soil contact, which is required for the germination of flowers. Aerification is the process of removing cores of soil from a turfgrass area to improve the flow of water and nutrients, which in this case allows for very good seed to soil contact and a space for new plants to begin growing. After parks were scalped and aerified, flower seed was dropped directly into the 800m^2 area. All flower seeds were placed into a calibrated drop spreader along with a starter fertilizer. All flower seeds were seeded at a rate of 241 seeds/9ft^2, with the exception of creeping thyme, which was seeded at a rate of 360 seeds/9ft^2. These seeding rates are the same as what was observed as acceptable in Phase One. The seeding rate of creeping thyme was increased to improve its establishment within bee lawns. Signage was placed in the center of each lawn to raise awareness for the project, and to reduce traffic during establishment.

These park enhancements will be maintained by the Minneapolis Parks and Recreation staff. They will be mowed once every 10-14 days. All parks, enhanced and clover only, will be visited once per week by a researcher. At each site visit, a 30 meter transect walk will occur for twenty minutes. During this time, all bee specimens observed along the transect will be collected via bee-vacuum. After the transect walk, bees will be placed in a cooler to preserve specimens. After the transect walk, forb establishment will be measured by dropping a 1m^2 grid every 5 meters along the transect line. All target flower blooms (blooms from flowers seeded on 11/22/16) within the grid will be counted. The presence of any non-target blooms (flowers not intentionally seeded) will be recorded. At enhanced parks, the presence of vegetation from seeded flowers will be recorded as well. Abiotic data (temperature, wind speed, relative humidity) will be recorded as well. After all data are collected from parks, specimens will be taken back to the University of Minnesota bee research facility where specimens will be pinned, identified, and databased.

Activity 1 Status as of October 2017:

In the summer of 2017, graduate student James Wolfin sampled the bee communities weekly in the 800 m^2 plots within 8 parks that were either enhanced (n=4) or unenhanced (n=4), as well as 8 additional Minneapolis parks. At the enhanced parks, bees were collected off of Dutch white clover, and any additional flowers that bloomed from the dormant seeding conducted in November 2016. Flowers from only one species, self-heal, bloomed in the enhanced plots at two sites: Audubon park in Northeast Minneapolis, and Kenwood park in Southwest Minneapolis. At unenhanced parks, bee pollinators were collected exclusively off of Dutch white clover. Sampling events consisted of walking a 30 meter transect for a duration of 20 minutes and collecting all bees using a non-destructive bee vacuum. Environmental data, including temperature, humidity, and collection time, were recorded by an undergraduate research assistant. To test if the abundance of bees was related to the number of blooming floral species at each site, the number of blooms was recorded by dropping a 1 m^2 grid every 5 meters on each side of the transect and counting blooms within the grid.

The bees caught during these surveys were pinned, identified, and databased at the University of Minnesota Bee Lab. At total of 2013 bee specimens were collected, including 40 unique species. Data analysis is underway to compare the diversity and relative abundance of bee species at enhanced and unenhanced parks. When possible, bees observed on self-heal were photographed to demonstrate the value of this flower to bee species. Soil samples were collected from each site to give insight towards the differential establishment of the flowers established via dormant seeding.

In late summer 2017 plug plants were ordered to supplement the flowers established via dormant seeding for the enhanced plots. Plug plants of self-heal (*Prunella vulgaris),* creeping thyme (*Thymus serpyllum)*, lanceleaf coreopsis (*Coreopsis lanceolate)*, and calico aster (*Symphiotrichum lateriflorum)* were purchased (128 plants for each species). At each enhanced site, 32 plants of each species were established within the plot area. Plants were spaced 2.5 m away from one another to minimize competition for nutrients and sunlight. After establishment, plants were watered for the following two weeks to improve establishment. A starter fertilizer was applied to improve root establishment for these plants. The methods used to collect data for bee abundance and diversity will be repeated in the spring of 2018.

Activity 1 Status as of April 2018:

Baseline data over three summers (2015-2017) on the diversity of bees that forage on white clover, *Trifolium repens*, already present in the 800 m^2 plots within 16 Minneapolis parks, has revealed 40 species, from a total of 4500 bees collected. The majority of bees (56%) were native bees, and 44% were honey bees, indicating that this flower species is an important food source for many bees in urban areas. Preliminary results comparing the diversity of bees at paired parks (clover-only parks vs. clover + florally enhanced parks) revealed a numeric trend, albeit not statistically significant, of higher bee diversity at enhanced parks based on a Shannon diversity index. Other statistical models are being used to determine what variables can predict bee abundance at enhanced sites.

This summer, 2018, we anticipate that the flowers planted within the enhanced plots will bloom, leading to greater floral diversity and thus greater bee diversity, compared to the clover-only plots. The methods used in previous summers will be repeated to collect data on bee diversity and abundance, floral bloom counts, and environmental data, in the paired park plots. An additional "meandering" transect will be run once per week, for twenty minutes at each enhanced park to identify the species of bees that forage on specific flowers.

Further tests will be performed at enhanced parks to determine why *Prunella vulgaris*, established and bloomed at only half of the enhanced plots in 2017. Water retention, turfgrass density and uniformity, and turfgrass species will all be analyzed, which will inform land managers and homeowners how to better establish a diverse flowering lawn.

Activity 1 Status as of October 2018:

The four enhanced field sites (Matthews, Audubon, Willard, Kenwood) were prepared with additional plug plants of self-heal (*Prunella vulgaris)* in April of 2018. Each site received five rows of eleven plugs, that were evenly spread throughout each field site. Plugs were irrigated for the first two weeks after planting only. After this point, no further irrigation was applied to the field sites. Self-heal blooms were observed at Audubon park, Kenwood park, and Willard park. In addition, creeping thyme blooms were observed at Willard park. The self-heal bloomed starting in early June, persisting through the start of August. The creeping thyme blooms were first observed in the middle of July, and persisted through the beginning of September.

Throughout the 2018 field season, paired parks were the primary focus of bee surveys. Fixed transects of 30 meters in length were run for 20 minutes once per week at each paired park, consistent with the methods utilized in previous field seasons. In addition to fixed transects, a meandering transect was run at enhanced field sites only, to allow for the low plant density observed in self-heal and creeping thyme, relative to the density of Dutch white clover. A meandering transect allows an observer to travel from between patches of target flora within a specified space, rather than being confined to a specific transect line. Meandering transects were run once per week at each enhancement park. These surveys lasted twenty minutes, and only took place when blooms of self-heal or creeping thyme were present. In the instance that both flowers were blooming within a given park, bee pollinators on both creeping thyme and self-heal were collected simultaneously. All

enhancement flowers within the 800 square meter area were recorded. Temperature, time of day, wind speed, and other abiotic data were recorded as well. Specimens were collected in separate containers based on the floral species they were collected off of such that host-plant identifications could be provided for each specimen.

During the 2018 field season, 1831 bees were collected in total, including 43 unique species. Thirty-five bee species were observed on Dutch white clover, 18 bee species were observed on self-heal, and 6 bee species were observed on creeping thyme. In total, 8 bee species were unique to enhancement flora, and were not observed on Dutch white clover. The most common bee species differed for each of the three flowers of interest: the most common bee species on Dutch white clover was *Andrena wilkella,* on self-heal was *Lasioglossum anomalum*, and on creeping thyme was *Augochlorella aurata*.

Preliminary results quantifying bee diversity at enhanced and untreated parks, using Shannon diversity indices (alpha diversity), suggested that local bee diversity was greater at enhanced parks. Beta diversity measures and NMDS plots will be used to compare bee communities between enhanced and untreated parks. Graduate student, James Wolfin, is projected to defend his Master's degree next summer, 2019.

Activity 1 Status as of April 2019:

Between 2016 and 2018 we observed wild bees and honey bees on flowers within turf lawns in Minneapolis public parks. In total, we conducted 280 site visits between the three years, including 58 in 2016, 126 in 2017, and 96 in 2018. Through these surveys, we were able to observe a total of 5264 bee specimens, including 62 unique bee species. Using a species prediction estimation, we predict that there are 72 bee species on flowering lawns in Minneapolis parks. On just Dutch white clover, we found 56 unique bee species, and predict that there were 64 bee species utilizing Dutch white clover in Minneapolis parks.

We observed bee diversity on clover only lawns and lawns that were enhanced with a seed mix containing Dutch white clover, self-heal, and creeping thyme. Over three years, we observed a higher mean bee diversity at enhanced parks compared to clover-only parks, based on Shannon's entropy index. In addition, enhanced parks support different communities of bees than clover-only parks. Out of the 103 bees observed on self-heal and creeping thyme, 100 were native bees, and no honey bees were observed on either of these flowers. These results provide evidence of the benefit to native bees by enhancing parks with additional species beyond Dutch white clover.

Based on the results of this study, we recommend that land managers plant a mixture of all three flowers, as our results indicate that these flowering lawns can support a high diversity of bees. We plan to continue surveying bees on flowering lawns in the spring and summer of 2019, focusing on enhanced parks. The total number of bees observed on enhanced flowers was low through the first two field seasons, and additional sampling would allow us to further document the bee species that use these flowers.

Activity 1 Status as of November 2019:

The work we have done has been well timed in that recommendation from our work can be used to enhance the success of the Lawns to Legume program currently being implemented in Minnesota. This legislatively-mandated program will allow Minnesota residents to use the knowledge we have gained in this project for the benefit of pollinators. James Wolfin, who will graduate with a Master's degree in Entomology in December 2019, began work at a local non-profit, Metro Blooms, where he is installing bee lawns across North Minneapolis as part of an environmental justice project in collaboration with the city of Minneapolis, and local community organizations including the Harrison Neighborhood Association. Through this project, 14 urban boulevards in North Minneapolis were planted with a bee lawn seed mix after lowering the ground level to capture more water and improving conditions of the soil for plant establishment. The bee lawn mix used in these boulevard plantings was designed by James Wolfin, Eric Watkins, and other members of the UMN turfgrass research team. The mix includes Dutch white clover, self-heal, creeping thyme, and a salt-tolerant fescue blend designed specifically for roadside conditions. Nearly 2000 square feet of bee lawn was planted through this initiative at 14 different residential properties in North Minneapolis. James Wolfin is further sharing knowledge on bee lawns through a workshop series led by the Board of Soil and Water Resources (BWSR) in collaboration with the Blue Thumb partnership and Metro Blooms. This workshop series features

both Train the Trainer workshops and workshops for residents where individuals learn about pollinator-friendly turf alternatives, including bee lawns.

Activity 1 Status as of April 2020:

James Wolfin graduated from the University with his Master's degree in Entomology. His thesis was on the diversity and community composition of bee lawns in Minneapolis, Minnesota. The findings show that florally enhanced lawns (lawns containing Dutch white clover, self-heal, and creeping thyme) contain more diverse and distinct bee communities than lawns containing just Dutch white clover. Seven bee species were found only on self-heal and were note observed on Dutch white clover during our surveys. Fifty-five species of wild bees were found foraging on Dutch white clover, and the vast majority were native species, although *Apis mellifera*, the European honey bee, was the most common species. In all, both florally enhanced lawns, and lawns containing just Dutch white clover provide floral resources for both native bees and honey bee populations.

The findings from this bee lawn research is impacting local and statewide pollinator conservation efforts. Bee lawn research conducted through this funding has led to the inclusion of pollinator lawns as an approved planting type for the Lawns to Legumes program, administered by BWSR. James in his current job at Metro Blooms continues to contribute to the implementation of Lawns to Legumes efforts, helping to lead the educational programming and technical assistance associated with the program. Findings from this research conducted is used in Lawns to Legumes educational workshops to encourage individuals to install bee lawns. Greater than 50% of survey respondents from workshops have indicated that they plan to install a bee lawn in 2020, and greater than 90% express an intention to install a bee lawn in the next two years. James is continuing to install bee lawns throughout Minneapolis through his work with Metro Blooms. He will be leading projects in the Near North neighborhood and the Bassett Creek Watershed that will include the conversion of traditional turf lawn boulevards into bee lawns. These bee lawns will both provide forage for pollinators and capture storm water runoff to improve local water quality.

We are currently working to transition James' thesis into a manuscript that will be submitted to the journal, *Urban Ecosystems* by May 31st 2020.

Activity 1 Status as of October 2020:

This activity was completed in April 2020.

Activity 1 Status as of April 2021:

This activity was completed in April 2020.

Final Report Summary:

Our work on this project has built upon a previous LCCMR funded project (M.L. 2013, Chp. 52, Sec. 2, Subd. 04h) and provides stakeholders with recommendations for establishment and maintenance of bee lawns, based on our research findings. Our research showed that florally enhanced lawns (lawns containing Dutch white clover, self-heal, and creeping thyme) contain more diverse and distinct bee communities than lawns containing just Dutch white clover. Fifty-five species of wild bees were found foraging on Dutch white clover, and the vast majority were native species, although *Apis mellifera*, the European honey bee, was the most common species. Seven bee species were found only on self-heal and were note observed on Dutch white clover during our surveys. Overall, both florally enhanced lawns, and lawns containing just Dutch white clover provide floral resources for both native bees and honey bee populations. The findings from this bee lawn research impact local and statewide pollinator conservation efforts. Bee lawn research conducted through this funding has led to the inclusion of pollinator lawns as an approved planting type for the popular Lawns to Legumes program, administered by the Minnesota Board of Water and Soil Resources, and educational workshops to encourage individuals to install bee lawns. Graduate student, James Wolfin, supported by this funding and now employed by Metro Blooms, is installing bee lawns throughout Minneapolis; e.g., in the Near North neighborhood and the Bassett Creek Watershed that will include the conversion of traditional turf lawn boulevards into bee lawns. These bee lawns will both provide forage for pollinators and capture storm water

runoff to improve local water quality. Recommendations on bee lawn establishment, based on our previous LCCMR funded project with insights from the current project, are a useful resource for Minnesota residents interested in helping increase the diversity of pollinator populations. As more stakeholders incorporate bee lawns, we will learn more about the need for future research; for example, there may be other flowering species that would work well in a bee lawn.

ACTIVITY 2: Showcase flowering lawns through demonstration plots, and evaluate landowner concerns and ideas about using flowering lawns.

Description: In Activity 1, we will establish large areas of florally enhanced turf at four parks in Minneapolis that are accessible by the public. We will add signage to each location giving visitors information about the current research and our findings from Phase 1 of this project. This information will likely be accessed with a QR code or other location-enabled technology. We will utilize these plots to learn about park users — their concerns and ideas about pollinators and florally enhanced lawns. Early interviews focus on what park users like about the parks, how they use them (particularly turf areas), and their knowledge about pollinators. Later interviews add the users' opinions about the flowering lawns. We will conduct these voluntary interviews of random park users with electronic tablet survey instruments. We will also invite stakeholders from Minnesota such as public land managers and maintenance personnel to visit the site for focus group interviews, so we can compare the unique challenges of implementation and management of these enhanced turf areas. All data from participants will be de-identified and we will carefully follow the protocols approved for these types of studies. This information will be used to develop general and targeted outreach materials as well as management protocols for public land managers.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 174,586
Amount Spent: $ 169,517
Balance: $ 5,069

Outcome	Completion Date
1.Develop outreach content describing florally-enhanced lawns and how they can help pollinators	March 2017
2. Place signs with outreach information at research sites in four parks in Minneapolis, and on Park Board website.	July 2017
3. Quantify number of distinct concerns and intensity of the concern by demonstration site park visitors, potential adjacent private land owners, and public park land managers.	September 2018
4. Develop presentations and suggestions for mitigation of these concerns that could be used by park managers in Minnesota who want to increase their use of florally-enhanced lawns in public parks, including improved educational materials, clear signage, web & social media info easily accessed and utilized by park managers, homeowners, and other stakeholders	June, 2019

Activity 2 Status as of October 2016:

Since Summer 2016 we have done cross-team training on pollinators and bee lawns, park site visits, met with Minneapolis Parks and Recreation Board (MPRB) planners, and initiated design of a pilot interview/survey guide. First, Dr. Kristen Nelson (Co-PI) and Hannah Ramer, Activity 2 research assistant, attended the Bee Lawn Field Day hosted by Dr. Spivak and Dr. Watkins in order to learn about specific management and ecological issues related to bee lawns and pollinators. In addition, this field day allowed us to meet a range of public land managers and private citizens interested in the topic of bee lawns. This informal yet content-rich setting provided an opportunity to understand current outreach approaches and potential audiences. Second, James Wolfin, Activity 1 research assistant, hosted Hannah Ramer and Dr. Nelson for a visit to all four enhanced bee

lawn parks, where Activity 2 will be conducted. We discussed the first season of planning for the location of the bee lawn plantings, the neighborhoods surrounding each park, and took photos of the parks and adjacent housing/businesses. Third, Dr. Nelson and Hannah Ramer met with Colleen O'Dell, MPRB planner to inform her about the Bee Lawn project and discuss past park user research, protocols for communication within the organization, and recommendations for how to best coordinate/collaborate with MPRB. Finally, Hannah Ramer began design of a methodology for pilot interviews and surveys to support development of effective outreach programs/communication.

Activity 2 Status as of April 2017:

Since October 2016, in relation to Activity 2, Hannah Ramer and Kristen Nelson developed a survey methodology to better understand park visitors' perceptions and concerns about enhanced flowering lawns. All the team members provided feedback for two drafts of the survey. The methodology is to survey visitors to the four parks where enhanced flowering lawns have been installed (Audubon, Willard, Kenwood, and Matthews). By varying the time of day, day of the week, and time of season in each park when we will be surveying, we will maximize the diversity of perspectives from park visitors who participate. The survey questionnaire was designed to elicit information that will help use develop community outreach materials and programming about enhanced flowering lawns, and will inform Minneapolis Park and Recreation Board decisions about how and where to implement enhanced flowering lawns in the future. In addition to eliciting information, the questionnaire was designed to share information about bee pollinators and enhanced flowering lawns with survey participants. Overall, this survey will help to inform our future efforts to examine the perceptions and concerns of adjacent land owners and public park land managers.

Activity 2 Status as of October 2017:

Since April 2017, the survey team conducted 149 hours of in-person surveying in the four study parks with enhanced flowering lawns, between May 30-August 25. All park visitors who were over 18 years old and proficient in English were invited to participate (though we did not interrupt active sports or play to recruit participants). We obtained a total of 538 completed surveys, which represents a 57% response rate. At this point the park user sampling is complete.

Throughout the summer we entered the survey responses into databases as we collected the surveys. In September, we began descriptive data analysis of frequencies and percentages for each survey question. This analysis is in progress. The first report should be complete in early November. It is designed as a preliminary analysis of findings to inform the Minneapolis Park and Recreation Board (MPRB) staff about park user knowledge of and attitudes about flowering lawns, pollinators, and the relationship with park uses. For example, participants were asked twice about how strongly they supported or opposed creating flowering lawns in Minneapolis public parks. When survey participants were first asked, 52% of participants strongly supported flowering lawns, 41% moderately supported, 3% moderately opposed. Only two participants indicated that they strongly oppose creating flowering lawns. Participants then answered questions about their attitudes towards bees, an info box regarding the differences between bees and wasps, as well as an info box that explained that white clover was already found to support bee pollinators and that the seeds for the enhanced flowering lawns were selected to increase the food value for honey bee and native bee pollinators. This information did seem to substantially increase the level of strong support for creating flowering lawns across all parks, though the effect was larger in some parks. Overall, when asked the second time, 65% of participants strongly supported flowering lawns, 26% moderately supported, 3% moderately opposed, and 1% strongly opposed. Findings such as these, and others, will inform future communication strategies and outreach materials for park users as well as management decisions about flowering lawns in the parks.

Our next steps are to continue data analysis, develop publications and presentations based on the 2017 survey, and design the 2018 survey for public land managers who attend the demonstration workshops in the summer of 2018.

Activity 2 Status as of April 2018:

As a team, we completed an analysis of the park user survey data and developed three products that can be used to inform the Minneapolis Park and Recreation Board (MPRB) staff and broader audiences about park user knowledge of and attitudes about flowering lawns, pollinators, and the relationship with park uses. The first is the *Park Visitors' Perceptions of Flowering Lawns in Minneapolis Public Parks Report* (Ramer, Nelson, Spivak, Watkins, and Wolfin 2018). The second is a flyer that synthesizes a few key insights from the park user study and Activity #1 2017 findings. This 2-sided flyer can be used for multiple audiences: MPRB officials, planners, managers, and park users. Finally, the third product is still in progress. Hannah Ramer developed a preliminary manuscript designed for publication in an applied academic journal. There is limited literature focused on public responses to flowering lawns and pollinator conservation in general. This manuscript supports Minnesota community discussions about using flowering lawns, higher education classroom instruction, and sharing insights about the Minneapolis experience at a national level. Our next steps are to finish the journal article and implement the 2018 discussions with public land managers/planners who attend the focus groups in the summer of 2018.

Activity 2 Status as of October 2018:

We completed several activities to share our findings on public perceptions of bee lawns from the 2017 park visitor survey: (1) Hannah Ramer presented "Park Visitor Perceptions of Flowering Lawns" at the International Symposium on Society & Resource Management in Alta, Utah in June 2018. (2) Hannah Ramer and Kristen Nelson completed a manuscript describing the findings from the 2017 park visitor survey. The paper was submitted to *Landscape and Urban Planning* in July 2018 and is currently under review. (3) Hannah Ramer contributed to an article "Redesign Your Rough: Implementing Conservation Practices in Low-Use Areas to Support Pollinators" in Hole Notes, the magazine published by the Minnesota Golf Course Superintendents Association. (4) Hannah Ramer was interviewed about bee lawns for a feature on Utah Public Radio "Redesigning Green Spaces into More Diverse Bee Spaces" (URL: http://www.upr.org/post/redesigning-green-spaces-more-diverse-bee-spaces).

Our objective was to examine the perceptions that public land managers have of flowering bee lawns. We conducted six focus group interviews with public land managers from across the Minneapolis-St. Paul Metropolitan Area. We invited public land managers from over 100 cities and counties park systems to participate, and we designed the recruitment process for the focus groups as mini-outreach opportunity. We recruited in-person at the August Turf Day Event during James Wolfin's Bee Lawn presentations. Next, our email recruitment correspondence included basic information about flowering bee lawns as well as a link to the Bee Lab's website with more in-depth information. In the end, 52 public land managers, representing 27 cities and counties, participated. The focus groups elicited information about perceived benefits of and barriers to adopting flowering bee lawns on public parkland that will be used to shape outreach and education efforts in the future. Furthermore, the focus groups served as outreach opportunities, including a general overview of flowering lawns as well as more technical information about seeding protocol.

Activity 2 Status as of April 2019:

We completed several activities to share our findings on public perceptions of bee lawns from the 2017 park visitor survey: (1) *Exploring park visitor perceptions of 'flowering bee lawns' in neighborhood parks in Minneapolis, MN, U.S.* (Ramer et al. in press), was accepted for publication in *Landscape and Urban Planning*. This article should reach a broad audience of landscape architects, city planners, park staff and diverse scholars. (2) Hannah Ramer and James Wolfin provided a guest lecture focused on Objective 1 & 2 findings for the American Lawn course at the University of Minnesota (11/11/18).

Also, our objective was to examine the perceptions that public land managers have of flowering bee lawns. We conducted six focus group interviews with public land managers from across the Minneapolis-St. Paul Metropolitan Area. Fifty-two public land managers, representing 27 cities and counties, participated. During this period, we transcribed focus group audio-tapes, established the theoretical frameworks for analysis and outlined initial paper topics. In addition, we worked with the whole team to begin planning the 2019 summer activities for a major field-day event for metropolitan land managers hosted by Minneapolis Park and Recreation Board collaborators. Finally, we began drafting materials for a *bee lawn toolkit* based on the benefits,

challenges, and questions that were identified by land managers in the focus groups. The managers identified this a desired outcome for the project as they are constantly evaluating trade-offs of distinct vegetation management options. A bee lawn toolkit would assist Minnesota public land managers, from beginners to those with established areas, step through the decision-tree analysis necessary for planning, implementation, maintenance, and public outreach.

Activity 2 Status as of November 2019:

We completed several activities related to the public perceptions of bee lawns and the development of outreach materials for public land managers and the general public: (1) we organized the Flowering Bee Lawn Event with the other team members, Audubon Park, Minneapolis, Public Land Manager talks and demonstrations 12:30-2:30 pm; General Public talks, 3:00-5 pm, July 31, 2019, in partnership with the Minneapolis Park and Recreation Board. (2) with team members we developed six signs for outreach about bee lawns, developed for municipalities and others to modify for their own municipal residents and programs (3) Hannah Ramer lead the production of a Land Manager Toolkit. *Ramer, H., Wolfin, J.E., Nelson, K.C., Spivak, M., Watkins, E., Nelson, K.C., Pulscher, M*. 2019. Flowering Bee Lawns: A Toolkit for Land Managers, August, 14 pgs. (online and electronic pdf). The Toolkit focused on the benefits, challenges, and questions that were identified by land managers in previous focus groups. The managers identified this as a desired outcome for the project as they are constantly evaluating trade-offs of distinct vegetation management options. The bee lawn toolkit can assist Minnesota public land managers, from beginners to those with established areas, step through the decision-tree analysis necessary for planning, implementation, maintenance, and public outreach. Over fifty land managers attended, representing municipalities, counties, landscape companies, public/private organizations (e.g. Science Museum). In the general public session, forty-six people signed the registration form and others joined the event without registering (i.e. children in the local MPRB recreation program).

In Fall of 2018, we conducted six focus group interviews with public land managers from across the Minneapolis-St. Paul Metropolitan Area. Fifty-two public land managers, representing 27 cities and counties, participated in the focus groups. to examine the perceptions that public land managers have of flowering bee lawns. Hannah Ramer, et al. have completed a first journal manuscript draft, currently titled, *"Using Ostrom's 'rules-in-use' to understand public land managers' perceptions of flowering bee lawns on parklands*".

Activity 2 Status as of April 2020:

We paused fieldwork and new initiatives during the winter months, working on journal articles and responding to land manager questions and media requests while the snow was on the ground. In March the COVID-19 essential staff requirements only allowed working within 'stay at home' guidelines and did not allow travel. We decided to hopefully be able to return to fieldwork and visit all the land managers' sites to see any installed bee lawns and maintained bee lawns or discuss possibilities there might be in the late spring and early summer of 2020.

Hannah Ramer (lead) and Kristen Nelson drafted, submitted, and revised a manuscript based on the land manager focus group data, titled *Applying 'action situation' concepts to public land manager's perceptions of flowering bee lawns in urban parks* for publication in *Urban Forestry and Urban Greening*. The article was recently accepted for publication in 2020. In addition, we responded to multiple media requests for comments and interviews associated with bee lawns, park user perceptions of bee lawns, and the benefits of bee lawns.

Bee lawns have become increasingly popular throughout the state of Minnesota as a result of this work. Many local plant retailers across the state of Minnesota have started to carry bee lawn mixes, flower seeds, and fine fescue grass. The Lawns to Legumes (L2L) program hopes to make pollinator friendly lawns a trend nationwide. Recently, the L2L team was invited to present information about L2L alongside state legislator Rick Hansen to the National Caucus of Environmental Legislators in an effort to promote pollinator friendly turf alternatives across the nation. We believe that the research conducted through this funding will inspire change nationwide.

Activity 2 Status as of October 2020:

During this period, Hannah Ramer and Megan Butler worked with the Bee Lawn research team to conduct informal interviews with Minneapolis-St. Paul metro area public land managers and when possible, due to COVID, site visits of municipal pollinator and bee lawn exhibits and plantings. The goal was to map existing bee lawns, gather information on establishment and maintenance, and identify communities with future plans for bee lawns. They interviewed 63 managers representing 51 entities most of whom attended the 2019 focus groups or outreach field-days. Plans for 2021 are to use these findings to inform future research by the bee lawn team and in our respective National Science Foundation or USDA NIFA research projects. In addition, we will develop new outreach materials based on the interview findings.

James Wolfin (graduate student from Activity 1) is using the knowledge he has gained to lead bee lawn installations at residential and commercial sites for Metro Blooms. He educates the public on bee lawns, leading workshops on Lawns to Legumes Resilient Yards and Turf Alternatives. He also led a bee lawn installation presentation on behalf of the Minnesota Landscape Arboretum for their annual Pollinator Summit, which was held virtually due to the complications associated with COVID-19.

Activity 2 Status as of April 2021:

During this period, Kristen C. Nelson and Eric Watkins worked with other scientists to design and successfully competed for funding that will support bee lawn and garden research integrated with other urban ecosystems questions over the next six years, and likely beyond: *National Science Foundation NSF DEB LTER. LTER: The Changing Nature of Cities: Ecological and Social Dynamics in the Minneapolis-St. Paul Urban Ecosystem.* Marla Spivak provided a collaborator letter from the Bee Lab. We see this an excellent extension and expansion of the LCCMR project that will build future collaborations with Minnesota State agencies, Twin Cities municipalities, non-government organizations and businesses.

Dr. Michael Barnes, in the Watkins Lab, gathered all the existing Bee Lawn social science data and research instruments, organizing the materials for easy access by the MSP LTER colleagues and other scholars. This will facilitate new interdisciplinary studies of residential bee lawns, with expansion to other institutional spaces such as parks, churches, and businesses.

We have continued to develop outreach materials that communicate how to establish a bee lawn and the benefits that these landscapes can provides for pollinators in Minnesota. Several new bee lawn outreach products have been prepared by Kristine Moncada (Turfgrass Scientist), Maggie Reiter (Turfgrass Extension Educator) and James Wolfin (Sustainable Landcare Manager at Metro Blooms). These include: a comprehensive website section, Planting and maintaining a bee lawn, with content on bee lawns on the UMN Extension Yard and Garden website written for a general audience of residents and land managers that will cover all aspects of bee lawn establishment and maintenance; and an article in Yard and Garden News, New Bee Lawn Resources from UMN Extension, that discusses the benefits of bee lawns and profiles the new website materials; a new handout Installing and maintaining a bee lawn for outreach at in-person events; and a Bee Lawn Seed webpage for Minnesotans to find bee lawn seed and mixes that will be updated regularly.

Final Report Summary

Our research findings show that Minneapolis park visitors supported implementing flowering lawns in public parks (97.2%). After informing the visitors that flowering lawns were designed to provide bee forage, those visitors with strong support for flowering lawns increased but on average, that was a slight decrease in support (95%). Overall positive perceptions of bees and flowers were positively related to support for bee lawns. Visitors most frequently mentioned aesthetics and helping bees as benefits and potential reduced recreational use and no concerns. Park user findings suggest widespread public support and informed our develop of outreach materials. Based on this study, we develop a 2-sided flyer for Minnesota land managers, non-government organizations, and businesses to inform the public. This content was distributed in talks, news outlets, workshops, municipal handouts, and multiple University and municipal websites. Our second initiative was working with municipal public land managers given their key role in decision-making regarding new vegetation options. In focus groups, starting with managers from 24 city parks departments, managers described the intertwined roles of the public, elected officials, and staff when considering a new vegetation practice such

as bee lawns. Across the managers, they are using three strategies — most common was actively educating the public and officials. Some managers used discrete experimenting with bee lawns before rolling out more extensive areas. Finally, some argued that reduced mowing and use of herbicides would 'sell' the idea; flowers were an added benefit. Currently, we shared the bee lawn findings in Minnesota through workshops, student class projects have developed plans and recommendations for specific metro-area cities, U.S. and international audiences have access to the academic publications, and a primary question in our new NSF project, MSP Long-term Ecological Research Project, was informed by and will continue social-ecological research and inform future outreach focused on bee lawns in relation to other vegetation options.

V. DISSEMINATION:

Description: At least two field days will be held at one of the enhanced parks, one each year in 2017 and 2018. These will be free and open to the public; we will advertise as appropriate to ensure good attendance. Researchers involved with this project will give talks and demonstrations on how to establish a flowering lawn and the benefits this type of lawn can provide. Throughout the project, we will post project updates and information to both the bee lab (beelab.umn.edu) and turfgrass science (turf.umn.edu) web sites. We will be in contact with appropriate state agencies, such as BWSR, about linking to project results on state agency websites. The Minneapolis Park and Recreation Board has close involvement with this project and will also post results and updates on their website. We will use social media to give updates on the project as well, specifically the Bee Lab and Bee Squad Facebook pages and the Bee Squad (@UmnBeeLab_Squad) and Turfgrass Science (@urbanturfmn) Twitter feeds. Results will be presented during field days (Minnesota Turf and Grounds Field Day on the UMN St. Paul campus); professional trade meetings (Northern Green Expo in Minneapolis each January); and scientific professional meetings (for example: Entomological Society of America, Crop Science Society of America and Society of Natural Resources). Additionally, we often receive requests from other group (Master Gardeners, garden groups, etc.) to speak and have a history of taking advantage of those opportunities.

Status as of October 2016:

The Bee Lab web site contains a page of information about "Flowering Bee Lawns" https://beelab.umn.edu/bee-lawn including a link to a downloadable pdf file that contains how-to information for planting flowering lawns. Since summer 2016, M. Spivak has delivered over 10 talks to groups (beekeeper, public, government agencies, etc.) in which she discussed the findings of Phase 1 of this project and plans for Phase 2. James Wolfin (graduate student) presented a talk on his current and upcoming research at the University of Minnesota Turf and Grounds Field Day, Woodbury Master Gardeners, the MN Hobby Beekeeping Association and Metroblooms.

Status as of April 2017:

The turfgrass science lab released a blog post about "Weeds in the Turf Lawn" to discuss the value that flowers that are often viewed as weedy species may have to our pollinators. This blog post focused on several of the flowers used in bee lawns, including Dutch white clover, creeping thyme, and self-heal. Other forbs not included within bee lawns that are of great interest to homeowners were discussed as well. This post was highly popular, and was featured in Bee Culture Magazine, one of the leading publications for beekeepers. The work from this project was presented at the 2017 American Bee Research conference, the Minnesota Turf and Grounds Field Day, the Northern Green Expo in Minneapolis, and at several master gardener and beekeeper associations. Additionally, this project is being featured as part of a "Resilient Yards Workshop", a twelve part workshop for Minneapolis homeowners, where the bee lawn project is featured as an alternative option to traditional turfgrass management practices.

Since October 2016, Hannah Ramer and Kristen Nelson developed a survey methodology to share information about bee pollinators and enhanced flowering lawns with survey participants. This survey will help to inform our signage at the bee lawns within the in parks selected for the study.

Status as of October 2017:

The Bee Lawn brochure, created as a collaborative effort between the bee lab, turfgrass science lab, and the Minnesota Landscape Arboretum was updated to include additional information about bee lawn flowers and management practices to improve the number of blooms. The work from this project was presented at 6 different outreach events between April and October, including the Minnesota State Fair at the Agriculture Horticulture Building, the City Parks Alliance Greater and Greener Conference (an international conference for public parks), and the Minnesota State Extension Master Gardener Conference. In addition to speaking opportunities, bee lawn seed packets have been distributed to community members at a number of outreach events including: The Minnesota State Fair and the Pollinator Party, an event hosted at Lyndale Park in Minneapolis, in partner with Minneapolis Parks and Recreation. Bee lawn research was also presented as a part of the Minnesota Nursery and Landscape Association and Minnesota Turf and Grounds Foundation Professional Lawn Care Workshop.

Status as of April 2018:

The work from this project was presented at 16 different research, teaching and outreach events from October to April. Presentations by J. Wolfin and H Ramer were dedicated entirely to this project.

Ramer, H., K.C. Nelson, M. Spivak, E. Watkins, and J. Wolfin in partnership with M. Pulscher. "Perceptions of Flowering Lawns in Minneapolis Parks" Guest lecture for The American Lawn (HORT 1942) freshmen seminar taught by Eric Watkins. October 23, 2017, St. Paul, MN.

Ramer, H., K.C. Nelson, M. Spivak, E. Watkins, and J. Wolfin in partnership with M. Pulscher. "Exploring perceptions of flowering lawns in Minneapolis neighborhood parks" Natural Resources Association of Graduate Students Symposium. April 25, 2018, St. Paul, MN.

Spivak, M. Friends of Itasca State Park Biological Station, "Status of Bee Health: Untying a Messy Knot" Sept 30 2017.

Spivak, M. Wisconsin Honey Producers Association, Eau Claire, WI. "Status of Bee Health: Untying a Messy Knot" Nov 3-4 2017.

Spivak, M. "Bee Health and Social Immunity" CA State Beekeepers Assoc, Lake Tahoe, CA. Nov 14-16 2017.

Spivak, M. "Bee Health in the U.S.A" Keynote speaker, Italian Beekeeping Assoc, Paestrum, Italy. Feb 1 2018.

Spivak, M. "Flipping the Perspective on Bee Health" N Carolina Beekeeping Association, Bern, NC. March 1 2018.

Spivak, M. "Exciting New Research at the University of MN Bee Lab" Wisconsin Beekeeping Assoc, Milton, WI. March 172018.

Spivak, M. "The Bee Research Lab, University of Minnesota" Falcon Heights – Lauderdale Lions Club, Falcon Heights City Council Chambers April 23, 2018.

Wolfin, J; Watkins, E; Spivak, M. "Evaluating bee communities in florally enhanced lawns". American Bee Research Conference, January 2018.

Wolfin, J., Evans, E., Brokaw, J., Boone, M. MN Master Naturalist Class: Native Bees of Minnesota. March 2018.

Wolfin, J., Dahm, B in partnership with Blue Thumb. "Turf Alternatives" Workshop. March 2018-June 2018.

Podcast appearance. Hyperlink Radio: Brands, Technology, and News. Beyond Beekeeping with James Wolfin, University of Minnesota. March 2018.

Wolfin, J., Watkins, E., Spivak, M., "Evaluating the abundance and diversity of bee pollinator communities in enhanced and natural turfgrass habitats". Entomology Society of America, North Central Branch Meeting. Invited symposium speaker. March 2018.

Wolfin, J., Watkins, E., Spivak, M. "Turning your lawn into a mowable bee lawn". Otten Bros Garden Center, Garden Workshop Day. April 2018.

Wolfin, J., Ramer, H., K.C. Nelson, M. Spivak, and E. Watkins in partnership with M. Pulscher. "Park Visitor Perceptions of Flowering Lawns" Lunchtime conference for Minneapolis Park and Recreation Board staff and City of Minneapolis Public Works staff. April 13, 2018, Minneapolis, MN.

Status as of October 2018:

Peer Reviewed publications:

Ramer, H., K.C. Nelson, M. Spivak, E. Watkins, J. Wolfin, and M. Pulscher. (2018) "Park Visitor Perceptions of Flowering Lawns." Manuscript in review.

Extension Publications:

Wolfin, J. and H. Ramer. (2018) "Redesign Your Rough: Implementing Conservation Practices in Low-Use Areas to Support Pollinators" Hole Notes 53:7, August p.22-37.

Conference Presentations:

Ramer, H., K.C. Nelson, M. Spivak, E. Watkins, J. Wolfin, and M. Pulscher. "Park Visitor Perceptions of Flowering Lawns." International Symposium on Society & Resource Management. June 2018, Alta, Utah.

Wolfin, J., Dahm, B in partnership with Blue Thumb. "Turf Alternatives" Workshop. October 2018.

Wolfin, J. Evaluating bee communities in florally enhanced lawns. University of Minnesota Horticultural Lightning Talks. September 2018.

Workshops and Field Days

Workshop Leader. Blue Thumb: Turf Alternatives. 4 part workshop series. Spring 2018.

Wolfin, J. "Managing lawns for native pollinators." University of Minnesota Turf and Ground Field Day. August 9, 2018. St. Paul, MN.

Press and Radio Releases

Installation of a native bee sculpture and bee lawn at the Weisman Art Museum. Spring 2018-Spring 2020. In collaboration with Colleen Satyshur (UMN Entomology) and Christine Baeumler (UMN Art Department)

Ramer, H. featured in Gayle, R. "Redesigning Green Spaces Into More Diverse Bee Spaces" Utah Public Radio. July 11, 2018. http://www.upr.org/post/redesigning-green-spaces-more-diverse-bee-spaces

Podcast appearance. Hyperlink Radio: Brands, Technology, and News. Beyond Beekeeping with James Wolfin, University of Minnesota. March 2018.

Status as of April 2019:

Peer Reviewed publications:

Ramer, H., K.C. Nelson, M. Spivak, E. Watkins, J. Wolfin, and M. Pulscher. (2018) "Park Visitor Perceptions of Flowering Lawns." In Press.

Lane I, Watkins E, Spivak M. 2019. Flowering Lawns: How turfgrass species and seeding rate affect establishment and bloom of a model forb, *Trifolium ambiguum. Hort Science* In Press.

Conference presentations:

Wolfin, J., Watkins, E., Spivak, M. "If you build it who will come? Evaluating the diversity of bees in flowering lawns. Entomological Society of America. November 2018.

Spivak, M. "Bee Lawns and Other Research from the University of Minnesota. "Ohio State Beekeeping Association, Columbus, OH. Nov 3 2018.

Spivak, M. "Bee Research Lab on the St Paul Campus" Falcon Heights – Lauderdale Lions Club, Falcon Heights City Council Chambers. April 23, 2018.

Workshops and Field Days:

Workshop Leader. Blue Thumb: Turf Alternatives. 2 part workshop series. Spring 2019.

Wolfin, J., Watkins, E., Spivak, M. "Building Better Lawns: How to Make Environmentally Friendly Lawns for your Community and your Pollinators". Your Yard and Climate Change: Protect, Redesign and Rebuild. April 2019.

Wolfin, J., Watkins, E., Spivak, M. "Turning your yard into a mowable bee lawn". St. Anthony Parks Commission Agenda. February 2019.

Informational bee lawn booth. Best Practices for Pollinators Summit. March 2019.

Wolfin, J., Watkins, E., Spivak, M. "Turning your yard into a mowable bee lawn". Super bee weekend presentation. February 2019.

Courses:

Wolfin, J., Ramer, H. Guest Lecture about Bee Lawns for HORT 4061W "Turfgrass Management" taught by E. Watkins, University of Minnesota. November 11, 2018.

Status as of November 2019:

The impact of our work is clear in the many questions we get about how to best install these pollinator habitats. Our team has conducted a number of workshops and give presentations to stakeholders on how to make lawns an important pollinator forage resource. During the Minnesota State Fair, the turfgrass science

team answered questions about low-input turfgrass management every day in the Agriculture/Horticulture building and found great interest in bee lawns. The team distributed a great number of bee lawn informational pamphlets and gave guidance on best practices.

The impact of our work has been further demonstrated through the adoption of pollinator lawns in the implementation of the "Lawn to Legumes" bill passed in May of 2019 in the state of Minnesota. This bill provides reimbursements to residents in the state of Minnesota that convert turf areas of their lawn to a pollinator friendly alternative. One of the options available for reimbursement through this cost-share program is converting your lawn, or a section of your lawn, into a bee lawn. The University of Minnesota's outreach documents are heavily featured in this program to aid in the installation of these bee lawns. Publications are in progress to publish the results of this work.

Peer Reviewed publications (updated citations)

Ramer, H., K.C. Nelson, M. Spivak, E. Watkins, J. Wolfin, M. Pulscher. 2019. Exploring park visitor perceptions of 'flowering bee lawns' in neighborhood park in Minneapolis, MN, US. *Landscape and Urban Planning,* 189: 117-128. https://doi.org/10.1016/j.landurbplan.2019.04.015.

Lane I, Watkins E, Spivak M. 2019. Flowering Lawns: How turfgrass species and seeding rate affect establishment and bloom of a model forb, *Trifolium ambiguum. Hort Science* 54(5): 824-828. https://doi.org/10.21273/HORTSCI13779-18

Workshops and Field Days:

Ramer, H., Wolfin, J.E. Watkins, E., Pulscher, M., Nelson, KC. Flowering Bee Lawn Event, Audubon Park, Minneapolis, Public Land Manager talks and demonstrations 12:30-2:30 pm; General Public talks, 3:00-5 pm, July 31, 2019, in partnership with with the Minneapolis Park and Recreation Board.

Ramer, H., Spivak, M., Watkins, E., Nelson, K.C., Pulscher, M. 2019. July 31, six signs for outreach about bee lawns, developed for municipalities and others to modify for their own municipal residents and programs.

Ramer, H., Wolfin, J.E., Nelson, K.C., Spivak, M., Watkins, E., Nelson, K.C., Pulscher, M. 2019. Flowering Bee Lawns: A Toolkit for Land Managers, August, 14 pgs. (online and electronic pdf)

Courses:

Wolfin, J., Ramer, H.R Guest Lecture about Bee Lawns for HORT 1942 "The American Lawn" taught by E. Watkins, University of Minnesota. November 11, 2019.

General publications

Carson, Teresa. "Growing golf courses that feed bees by Teresa Carson. September 2019 issue of Golf Course Management online magazine <https://www.gcmonline.com/course/environment/news/flowering-bee-lawns> This article featured bee lawn work from the Turfgrass Science Lab and the Bee Lab.

Fosdick, Dean. "Save the bees (and time and money) by creating a bee lawn". *The Washington Post*. May 28, 2019. Graduate student James Wolfin was interviewed for this article that has highlights from his research on bee lawns.

Example Reports on Partner Demonstration Plots and Installations:

Hamilton, Patrick reported that the Science Museum planted a bee lawn on the Museum grounds, after attending the Public Land Manager Bee Lawn Field Day in July. They will provide signage for visitors.

Redlin, Erin Jordahl reported establishing a flowering bee lawn in the St. Anthony Park municipality and used the signs to inform the community members about the City was doing.

Status as of April 2020:

The impact of our work continues, primarily through publications and media interest. In the next phase, we will contact all the land manager participants in field days and focus groups to identify where they have installed the bee lawns or plan to install bee lawns this coming summer. We will map these sites and any other bee lawn sites they are aware of in their communities. Landscaping companies have been promoting bee lawns as one of their offerings and we plan to identify the sites, both residential and public, that they installed. In late

July, if travel conditions allow, we will visit all the sites to evaluate the vegetation. Also, conduct brief interviews with the land managers about the first year with bee lawns and plans for the future.

Peer Reviewed publications

Lane IG, Wolfin J, Watkins E, Spivak M. 2019. Testing the establishment of eight forbs in mowed lawns of hard fescue (*Festuca brevipila)* for use in pollinator conservation. *Hort Sci*. 54(12): 21-50-2155. doi.org/10.21273/HORTSCI14336-19

Ramer, H. and K.C. Nelson. 2020. Applying 'action situation' concepts to public land manager's perceptions of flowering bee lawns in urban parks. *Urban Forestry and Urban Greening* (in press).

Media Coverage

Streeter, Ben. "Bee Lawns Generate National Buzz" *Stateline*. Pew Charitable Trusts. 10 March 2020. https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2020/03/10/bee-lawns-generate-national-buzz

Philpott, Tom. "Your Perfect Green Lawn Is a Buzz Kill. Here's how to turn it into a pollinator party." *Mother Jones*. 7 May 2020. https://www.motherjones.com/food/2020/05/your-perfect-green-lawn-is-a-buzz-kill/

Koski, Madeleine. "Three Ways Minneapolis Parks are Promoting Pollinator Friendly Environments." Minneapolis Parks Foundation. 20 February 2020. https://mplsparksfoundation.org/2020/02/20/three-ways-minneapolis-parks-are-promoting-pollinator-friendly-environments/

Status as of October 2020:

Peer Reviewed publications

Updated citation: Ramer, H. and K.C. Nelson. 2020. Applying 'action situation' concepts to public land manager's perceptions of flowering bee lawns in urban parks. *Urban Forestry and Urban Greening,* 53, 126711. https://doi.org/10.1016/j.ufug.2020.126711.

ESPM 4041 student project on Bee Lawns for Hopkins Minnesota. *Community Engaged Strategies for Implementing Bee Lawns*, Famy, N, J. Holdreith, E. Locke, C. Macke, and H. Weber, Report #7 (67 pgs.), City Council Presentation Dec.15th, example website for outreach to the community.

Conference Presentations

Wolfin, James. 2020. *Pollinators and Policy: A Successful Minnesota Response*", Pollinator Summit Series hosted by the University Minnesota Landscape Arboretum.

Status as of April 2021:

National Science Foundation NSF DEB LTER. LTER: The Changing Nature of Cities: Ecological and Social Dynamics in the Minneapolis-St. Paul Urban Ecosystem*****, S. Hobbie, (PI) Co-PIs: B. Keeler, K. Nelson, X. Feng, J.C. Finlay, (co-PIs). $7,126,200. 2/2021-2/27.
Senior Investigators: L. Baker, L. Brandt, K. Brauman, J. Cavender-Bares, M. Davenport, K. Derickson, M. Dockry, F. Fleischman, J. Gulliver, S. Ishii, N. Jelinski, D. Karwan, C. Kazanski, J. Knight, S. Lerman, E. Lonsdorf, H. Menninger, R. Montgomery, J. Neiber, G. Small, E. Snell-Rood, T. Twine, E. Watkins.
***Leveraged LCCMR grant findings and networks to support a long-term socio-ecological study of bee lawns and gardens. (K. Nelson (Q3.) and E. Watkins (Q1.3) – investigators)**

Moncada, K. 2021. Other fine fescue research at the University of Minnesota: Bee lawns. Low Input Turf Blog. https://lowinputturf.umn.edu/other-fine-fescue-research-university-minnesota-bee-lawns

Status as of grant end:

- Moncada, K., M. Reiter, and J. Wolfin. 2021. Planting and maintaining a bee lawn. https://extension.umn.edu/landscape-design/planting-and-maintaining-bee-lawn
- Moncada, K. and M. Reiter. 2021. New bee lawn resources from Extension. https://extension.umn.edu/yard-and-garden-news/extension-research-help-you-help-pollinators

- Moncada, K. and M. Reiter. 2021. Installing and maintaining a bee lawn. https://turf.umn.edu/sites/turf.umn.edu/files/2021-07/Installing%20and%20maintaining%20a%20bee%20lawn_0.pdf
- Bee Lawn Seed webpage - https://turf.umn.edu/lawn-info/purchasing-seed/bee-lawn-seed

Final Report Summary:

There has been an amazing amount of interest by the general public on the topic of bee lawns. We have been fortunate in our dissemination efforts to reach not only countless Minnesotans with our work, but have also received coverage by the media on a national level with articles in the Washington Post, Mother Jones, and Stateline. Dozens of talks, workshops, podcasts, field days, classroom lectures, and scientific conference presentations have been given by the PI and coPIs, and graduate students James Wolfin, Hannah Ramer and Ian Lane. Four peer-reviewed publications have been published on research from this grant. Bee lawn materials have been published on three different UMN websites, all of which are accessible and will reach different audiences (the general public on the UMN Extension site, turfgrass audiences on the Turfgrass Science website and entomology audiences on the Bee Lab website). For example, the Turfgrass Science bee lawn materials have received over 30,000 pageviews since they were published.

Since our last report, several new bee lawn outreach products have been prepared by Kristine Moncada (Turfgrass Scientist), Maggie Reiter (Turfgrass Extension Educator) and James Wolfin (Sustainable Landcare Manager at Metro Blooms and former graduate student with the project). The first item is a comprehensive website section, *Planting and maintaining a bee lawn*, with content on bee lawns on the UMN Extension Yard and Garden website written for a general audience of residents and land managers that covers all aspects of bee lawn establishment and maintenance. The UMN Extension website gets hundreds of thousands of visits every year. We anticipate that this content will become the go-to resource for all Minnesotans who are interested in having their own bee lawns. The second resource is an article emailed to thousands of subscribers of Yard and Garden News, called *New bee lawn resources from UMN Extension*, that discusses the benefits of bee lawns and profiles the new website materials. The third resource is a new handout Installing and maintaining a bee lawn for outreach at in-person events such as field days and the Minnesota State Fair. Lastly, we created a Bee Lawn Seed webpage for Minnesotans to find bee lawn seed and mixes, as well as installers of bee lawns, that will be updated regularly.

Even past the grant end, outreach for bee lawns will continue. UMN Extension and the UMN Turfgrass Science team will publish a series of topical articles over the next few months in Yard and Garden News on bee lawns (such as Bee lawns: Keeping your neighbors happy, Now is the time to dormant seed bee lawns, No-Mow May and bee lawns, Managing weeds in bee lawns, and De facto bee lawns: Dutch white clover in your lawn). We will also create a template on bee lawns for cities on their websites so they can link to our Extension materials. We will give a presentation on bee lawns and the new outreach materials at the Master Gardener field day on 9/13/21. The Turfgrass Science team will be at the Minnesota State Fair everyday (8/26/21-9/6/21) to answer lawn and bee lawn questions and we will have handouts on bee lawns and examples of bee lawn plants. And finally our team will continue to collaborate with Extension and CFANS to promote new bee lawn materials. We expect to reach many thousands of Minnesotans with our work.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 364,165	1 Project manager and 2 collaborator at 4.1% FTE each year for 3 years ($64,021); 2 graduate research assistants at 50% FTE each year for 3 years ($242,410); 1 research technician at 13% FTE each year for 3 years ($32,532); 2

		undergraduate assistants at 3% and 1.5% FTE each summer for 3 years ($25,222)
Equipment/Tools/Supplies:	$2,400	Supplies for demo sites (seed, fertilizer for establishment, biodegradable germination blankets, etc.) Estimated $800/ year ($2,400)
Printing:	$4,000	Educational and Outreach Materials: e.g., signs, brochures, handouts, pubs, press releases, fact sheets, estimated $1,300/ year for 3 years ($4,000)
Travel Expenses in MN:	$9,000	Vehicle expenses (leasing from UMN, gas, mileage) to visit Mpls Park research plots during summer months; estimated $3000/ year for 3 years ($9,000)
Other:	$7,500	Survey research estimated $500/ year; mailings, data analysis, info materials, website work and additions; specific event expenses (tent rental, refreshments) estimated at $2,305/ year for 3 years ($7,415)
TOTAL ENRTF BUDGET:	**$387,000**	

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 3.89

B. Other Funds: NA

VII. PROJECT STRATEGY:

A. Project Partners:

Project partners not receiving funds:

- Minneapolis Park and Recreation Board, providing assistance in locating Minneapolis parks for Activity 1, and in survey work for Activity 2
- Board of Water and Soil Resources, assistance with sourcing of local seeds for flowering lawns (see letter from Dan Shaw, BWSR).

Project partners receiving funds:

- Dr. Eric Watkins, Associate Professor, Horticultural Science, University of Minnesota, will co-advise the graduate student for Activity 1 and assist in project design and implementation.
- Dr. Kristen Nelson Professor in Forest Resources, and in Fisheries, Wildlife, and Conservation Biology, University of Minnesota, is natural resource sociologist who will advise a second graduate student in Objectives 3 and 4 of Activity 2, and assist with project design and implementation.

B. Project Impact and Long-term Strategy: Minnesota is leading the nation in legislative initiatives to help pollinators, and as a result, public awareness about the plight of pollinators is at an all time high. The addition of native flowers into turf will provide nutritional resources for pollinators, and will reduce intensive inputs of water, fertilizers and pesticides. Flowering lawns could provide a natural buffer to water resources in areas where low-growing, more manicured looking lawns are preferred. Flowering lawns would beautify Minnesota, protect our natural resources, and help achieve important state and federal pollinator protection initiatives.

As we are working with native seed growers and the Board of Water and Soil Resources (BWSR) to develop local seed sources for this plant, this project will increase availability of seed for use by the homeowners and businesses that want to plant flowering lawns. Our combined extension and outreach experience will ensure that we continue to disseminate information about the benefits of flowering lawns and how best to incorporate them to protect and enhance our natural resources.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
ENRTF Bee Pollinator Habitat Enhancement M.L. 2013, Chp. 52, Sec. 2, Subd. 04h	July 1, 2013 – June 30, 2016	$200,000

IX. VISUAL COMPONENT or MAP(S): attached

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than October 2016, April 2017, October 2017, April 2018, October 2018, April 2019, October 2019, April 2020, October 2020 and April 2021. A final report and associated products will be submitted between June 30 and August 15, 2021.

Environment and Natural Resources Trust Fund
M.L. 2016 Final Project Budget

Project Title: Bee Pollinator Habitat Enhancement – Phase II
Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 08a
Project Manager: Marla Spivak
Organization: University of Minnesota
M.L. 2016 ENRTF Appropriation: $387,000
Project Length and Completion Date: 3 Years, June 30, 2019
Amended Project Length and completeion Date: 5 years, June 30, 2021
Date of Report: October 13, 2021

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget 6/28/19	Amount Spent	Activity 1 Balance	Activity 2 Budget 6/28/19	Amount Spent	Activity 2 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM								
Personnel (Wages and Benefits)	$201,684	$201,684	$0	$167,284	$166,939	$345	$368,968	$345
Partial summer salary (0.5 month, 66% salary, 34% fringe benefits, 4.1% FTE each person, each year for 3 years): Project Manager Marla Spivak (total 3 yrs $29,917), and collaborators E. Watkins (3 yrs = $15,574) and K. Nelson (3 yrs = $18,530). Total = $64,021		$39,428			$24,218			
Graduate Research Assistants, 1 Masters (total 3 yrs = $137,264), 1 PhD (total 3 yrs = $105,147). 51% salary + 49% fringe benefits and tuition, except for PhD student on advanced GRA, reduced fringes). 50% FTE each student, each year . Total = $242,410		$118,596.49			$125,087			
Research Technician, Andrew Hollman (79% salary, 21% fringe benefits) 13% FTE each year for 3 years. Total = $32,532		$32,637			$14,478			
UndergraduateField Assistants, 100% salary for two students, 3% FTE each year for 3 years for first student. 1.5 FTE/ year for 3 years for second student ,$12,611 each student for 3 yrs; Total = $25,222		$11,022			$3,156			
Equipment/Tools/Supplies								
Supplies for demo sites (seed, fertilizer for establishment, biodegradable germination blankets, etc.) Estimated $800/ year for 3 years	$1,789	$1,789	$0					$0
Printing								

Educational and Outrach Materials: e.g., signs, brochures, handouts, pubs, press releases, fact sheets, estimated $1,333/ year for 3 years				$4,000	$1,346	$2,654		$2,654
Travel expenses in Minnesota								
Vehicle expenses (leasing from UMN, gas, mileage) to visit Mpls Park research plots during summer months; estimated $3000/ year for 3 years	$8,941	$8,941	$0					$0
Other								
Survey research estimated $500/ year; mailings, data analysis, info materials, website work and additions; specific event expenses (tent rental, refreshments) estimated at $2,305/ year for 3 years				$3,302	$1,231	$2,071		$2,071
COLUMN TOTAL	**$212,414**	**$212,414**	**$0**	**$174,586**	**$169,517**	**$5,069**	**$387,000**	**$5,069**

Bee Pollinator Habitat Enhancement – Phase 2

Flowering Lawns

M. Spivak, E. Watkins, K. Nelson, UMN
and Minneapolis Park and Recreation Board

Outcomes:

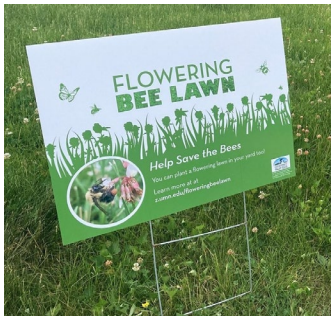
- Support bee health and nutrition
- Reduce intensive inputs on turf – water, fertilizer, pesticides, mowing
- Protect and enhance Minnesota natural resources

A florally enhanced fine fescue lawn

Lawn with only Dutch white clover

Activities:

1) Our research found lawns with Dutch white clover, self-heal, and creeping thyme have more diverse and distinct bee communities than lawns with just Dutch white clover.
2) We created a toolkit for Minnesota public land managers with the steps to plan, implement, and maintain pollinator lawns, and address public concerns.
3) We developed accessible educational materials on the University of Minnesota Extension website to help Minnesota residents plant and maintain bee lawns of their own.



Bee lawn yard sign

A diversity of flowering plants in fine fescue lawns provides more forage for pollinators

Prunella vulgaris var. *lanceolata*
Self-heal

Thymus praecox ssp. *arcticus*
Creeping thyme

Trifolium repens
Dutch white clover