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

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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^{2}x20m^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^{2}x20m^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

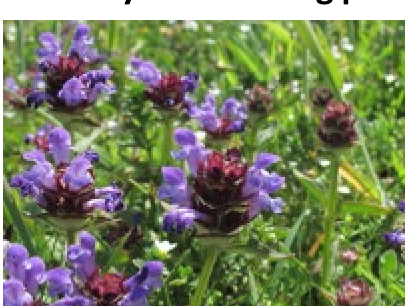
Lawn with only Dutch white clover

Activities:

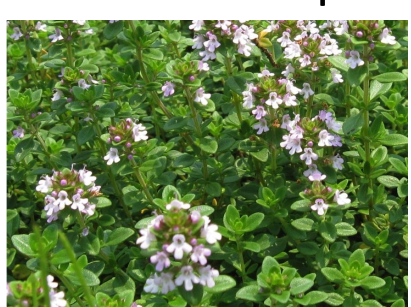
1) Our research found lawns with Dutch white clover, self-heal, and creeping thyme have more diverse and distinct bee communities than lawns with just Dutch white clover.
2) We created a toolkit for Minnesota public land managers with the steps to plan, implement, and maintain pollinator lawns, and address 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

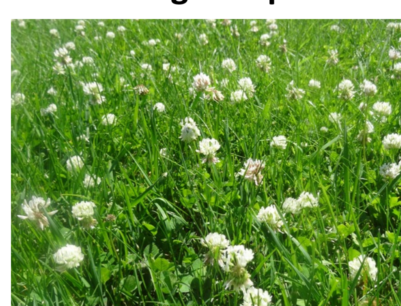
A diversity of flowering plants in fine fescue lawns provides more forage for pollinators



Prunella vulgaris var. *lanceolata*
Self-heal



Thymus praecox ssp. *arcticus*
Creeping thyme



Trifolium repens
Dutch white clover

FLOWERING LAWNS

in Minneapolis Parks

The Minneapolis Park & Recreation Board is collaborating with the University of Minnesota to research flowering lawns as a concrete way to increase nutritional resources for bee pollinators in urban areas.

Do flowering lawns support a diversity of bees?
What do park visitors think of flowering lawns?

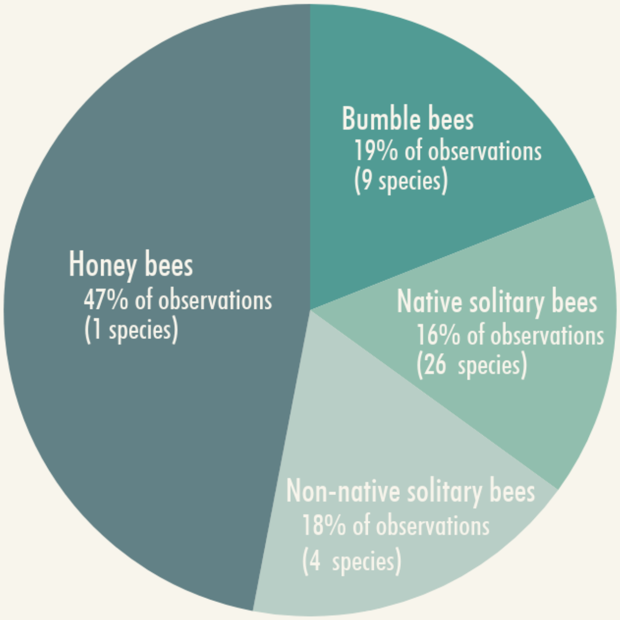
The populations of many bees are declining, in part due to lack of food availability. Adding low-growing flowers to turf grass lawns can provide food for bees and maintain recreational opportunities.

White clover (*Trifolium repens*) is already common in lawns throughout Minneapolis.

In 2015 and 2016, researchers from the U of M Bee Lab found that...

40 species of bees forage on white clover in Minneapolis parks

Proportion of bees observed on white clover in Minneapolis Parks (2015-2016)

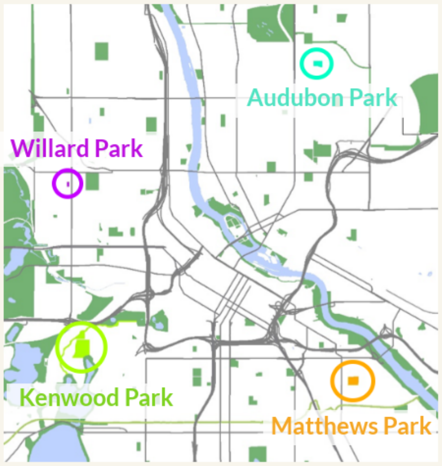


Enhanced Flowering Lawns & Bee Diversity

In late fall 2016, we planted **enhanced flowering lawns** with a mix of several flowers at four Minneapolis parks.

Once fully established, they will include calico aster, creeping thyme, lanceleaf coreopsis, and self-heal, as well as white clover.

Self-heal and white clover



Minneapolis parks with enhanced flowering lawns

Preliminary results from 2017 suggest that **increasing floral diversity can lead to greater bee diversity.**

Some native bee species, like *Melissodes bimaculata* & *Osmia pumila* (pictured), were only observed in parks where self-heal bloomed.

Osmia pumila

Dutch White Clover

Creeping Thyme

While **non-native flowers** may be aggressive, they can still be very useful.

Dutch white clover *(Trifolium repens)* and creeping thyme *(Thymus serpyllum)* are two species that benefit pollinators and will flower in a mowed lawn.

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

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

Planting a bee lawn is best in late fall as a dormant seeding, ideally when soil temperatures dip below 40°F.

Germination will not occur until the following spring when soil temperatures rise above 50°F.

Dormant seeding reduces pressure from surrounding weeds that may be competing for resources.

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

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

MANAGING BEE LAWNS

Mowing: The one-third rule is a good guide: do not mow more than one-third of the vegetation at one time to a height between 3.5 and 4 inches to ensure that flowering plants survive and produce flowers to sustain pollinators.

Watering: Soil moisture should be monitored. White clover and fine fescue grasses are quite drought-tolerant but may need supplemental watering after several weeks with no rain.

Fertilizing: A soil test (visit soiltest.cfans.umn.edu) will determine if nutrients need to be added. Fertilizer requirements will be minimal if clippings are returned, mowing heights are kept high, and soil quality is good.

Weeding: Hand weeding is the preferred option, with spot treatments with selective herbicide as needed. Learn which weeds have value to pollinators, are diverse and add to a long flowering season for bees and other pollinators.

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

FOR MORE INFORMATION

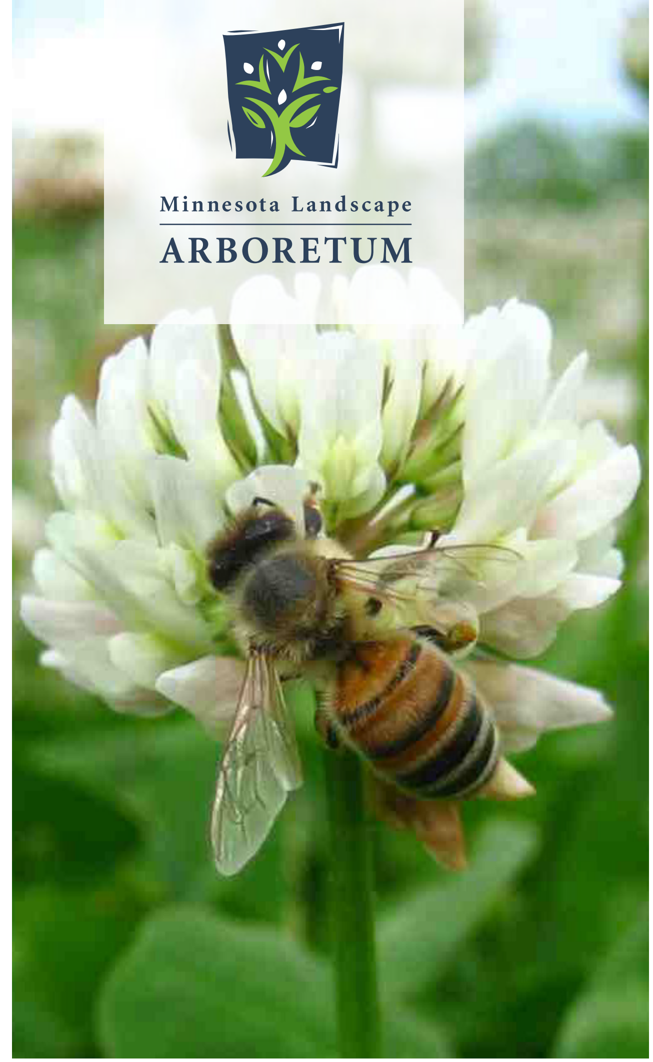
University of Minnesota Landscape Arboretum
arboretum.umn.edu/gardensandcollection.aspx

University of Minnesota Bee Lab
beelab.umn.edu/bees

University of Minnesota Turfgrass Science
turf.umn.edu

University of Minnesota Extension
extension.umn.edu

Mary Meyer, Marla Spivak, Eric Watkins and James Wolfin



Bee Lawns

Turf Grass with Flowering Plants

University of Minnesota Extension

BENEFIT OF BEE LAWNS

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

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

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

ENHANCE YOUR LAWN TO PROMOTE POLLINATORS

A new bee lawn can be established from a seed mixture of grass and flowers or by seeding flowers into an existing lawn. Seeding into an existing lawn is less expensive but can be challenging to establish, as new flowers compete for space with grass. Good seed germination requires adequate moisture, good soil to seed contact and erosion protection. For best results, try scalping (mowing grass to 1 inch or less), aerating and then adding flower seed. Find information at: beelab.umn.edu/bees

GRASSES TO USE

Native Fine Fescues grow slowly and do not compete against bee-friendly plants. Fescues are main components of shady lawn mixtures but grow well in full sun. They tolerate drought and low soil fertility, making them good choices for flowering lawns.

Kentucky Bluegrass* establishes slowly, allowing non-native flowering plants to grow along with the lawn. It requires more intense management than fine fescue grasses.

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

NATIVE FLOWERS FOR BEE LAWNS

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

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

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

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

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

Bee Lawns: Installing

CHOOSING YOUR SITE

Site location is important. It should be a place where bee lawn plants will thrive and bloom. Things to consider:

- Avoid deep shade as that will lead to sparse flowers and thin turf.
- Take your neighbors into consideration. Some of the flowers may spread to adjacent areas. Will that cause issues?
- What are the lawn maintenance rules in your municipality? Maybe your backyard may be more appropriate for a bee lawn depending on city codes.
- A low-traffic area will work better to avoid stepping on foraging bees!

Remember, it's okay to start small rather than converting your entire yard at all once.

WHEN TO ESTABLISH

Times to establish bee lawns in Minnesota are:

1. **Dormant seeding** in the late fall. This is the best time and will result in less work. In this technique, the seed is spread after the soil is too cold for germination. This is usually in late October to early November. The seed then germinates the following spring.
2. **Spring seeding** in May. This can work well, but there will be more challenges with weeds. Seed is spread after risk of frost in mid to late May. Unlike dormant seeding, the site will need to be watered regularly after planting.

Either of these times can work with **how you choose to establish** (next section).

HOW TO ESTABLISH

Choosing how to establish is one of the trickier aspects of a bee lawn. Options are:

1. **Overseeding.** Use this option if you have a healthy lawn with few weeds. The first step is to set back the existing turf by mowing the lawn very short to about one inch. The goal is to have some soil exposed. You can also aerate to help even more, especially with compacted soil.
2. **Renovation.** In this option, all the existing lawn is removed, either with a sod kicker or sod cutter, or by solarization. The soil should be lightly tilled and raked smooth before planting.

SEEDING

Once the site is ready, the seed can be spread. Here is an example of a recommended mixture, which would cover about 1000 ft^2.

- Fine fescue turfgrasses – 4 lbs.
- Dutch white clover – 1.1 oz.
- Self heal – 1.2 oz.
- Creeping thyme – 0.16 oz.

Bee lawn seed mix already pre-mixed can be found at some retailers (see *For More Information*).

AFTER SEEDING

For bare soil renovations, rake in seed lightly. Water regularly if establishing in the spring; watering is not needed if dormant seeding. You can use a starter fertilizer (this will be labeled as such at your garden or hardware store) for the spring planting, but it is not needed for dormant seeding.

Bee Lawns: Maintaining

MOWING

Bee lawns can be maintained similarly to regular lawns. Mowing can help set back some weeds and can encourage further flower blooming. Mowing should be:

- Done at a higher height, so adjust your mower to 3 inches or more
- Performed less frequently to allow for flowers to bloom
- Postponed when the flowers are at the height of their bloom to allow pollinators time to forage from them

WATERING & FERTILIZING

Once established you probably will not need to water much at all. In long periods of drought, you may need to do a few deep waterings.

Bee lawns need little to no supplemental fertilizer once established. Too much fertilizer will favor the turfgrass over the flowers.

WEEDING

One thing to know about bee lawns is that you can't use most herbicides if you want to keep the flowers. You can:

- Hand pull weeds
- Learn to tolerate a few weeds
- Spot treat with an herbicide if necessary

Be careful with "weed and feed" products because they may contain herbicides that could kill your bee lawn flowers.

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

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WHAT TO EXPECT

- The flowers may take some time to establish, be patient.
- If by the 2nd year there are few flowers, consider trying again, maybe using a different way to establish.
- Your bee lawn may not be uniformly "flowery"; some flowers may do well in one part of your lawn, while less well in others.
- Bee lawns attract many species of pollinators, not just bees; you may see butterflies, moths, flies, beneficial wasps and more!

FOR MORE INFORMATION

This publication discusses the basics of establishing and maintaining a bee lawn. You can find much more information at the following sites:

- **UMN Bee Lab** beelab.umn.edu
- **UMN Extension** extension.umn.edu
- **UMN Turfgrass Science** turf.umn.edu
- **MN BWSR Lawns to Legumes Program** bwsr.state.mn.us/l2l
- **Metro Blooms** metroblooms.org

For a listing of where to purchase bee lawn seed: z.umn.edu/buyseed

One final note. Don't forget that bee lawns are just a small part of helping pollinators. Consider adding native trees, shrubs, and other flowering plants to your landscape.

HortScience 54(12):2150–2155. 2019. https://doi.org/10.21273/HORTSCI14336-19

Testing the Establishment of Eight Forbs in Mowed Lawns of Hard Fescue (*Festuca brevipila*) for Use in Pollinator Conservation

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Additional index words. bee lawn, flowering lawn, reconciliation ecology, urban diversity

***Abstract*. Public concern for the conservation of pollinating insect communities, such as bees, has created demand for more florally diverse landscapes. In urban environments, lawns form a large portion of cultivated land, and are typically managed to exclude flowering species richness. In this study, we investigated the establishment of eight flowering plants with pollinator value (plants that provide floral nectar and pollen for visiting insects) when coseeded with the turfgrass hard fescue (*Festuca brevipila* Tracey). The study was established as a dormant seeding at two locations in central Minnesota with substantially different soil types. Plots were maintained at either a 6- or 9-cm mowing height. We monitored these plantings over the 2014, 2015, and 2016 growing seasons for vegetative establishment and flowering of planted forbs. Of the eight forbs tested, *Trifolium repens* L., *Prunella vulgaris* ssp. *lanceolata* (W. Bartram) Hultén, *Thymus serpyllum* auct. non L., and *Astragalus crassicarpus* Nutt. established in at least one location. Mowing height did not affect vegetative establishment, but had a negative effect on the number of blooms produced by *P. vulgaris* ssp. *lanceolata*. Vegetative establishment was affected by location, with *P. vulgaris* ssp. *lanceolata* establishing in higher abundance in the moist loamy site, whereas *T. serpyllum* and *A. crassicarpus* established in higher abundance at the dry sandy site. This study represents an important first step in identifying appropriate plants and management practices for improving lawns as a resource for pollinators.**

Pollination is an important ecosystem service valuable to both agriculture (Losey and Vaughan, 2006; Rader et al., 2015; Southwick and Southwick, 1992) and natural systems (Grubb, 1977; Ollerton et al., 2011). One group of pollinators, bees (Hymenoptera: Anthophila), has been of particular concern due to rapid declines of many species over the past 40 years (Goulson et al., 2015). These declines have generated increased public concern and an interest in their conservation (Wilson et al., 2017). One of the primary methods of conserving pollinators is through the addition of forbs that provide pollen and nectar resources in the landscape (Murray et al., 2009). This method has proven effective in increasing pollinator abundance and species richness in farm borders (Blaauw and Isaacs, 2014; Morandin and Kremen, 2013), roadside verges (Noordijk et al., 2009, Hopwood et al., 2010), green roofs (Braaker et al., 2014), and neighborhood gardens (Pawelek et al., 2009). Despite this progress, modifying landscapes to meet both anthropogenic and biodiversity conservation goals in tandem remains an important area of research, and has been coined reconciliation ecology (Rosenzweig, 2003).

Urban areas are a sector of anthropogenic land use that occupies roughly 3% of total U.S. land area and is the fastest expanding use of land, having quadrupled in cover since 1945 (Bigelow and Borchers, 2017). The challenges and opportunities of conserving nature in urban habitats have been well reviewed (Goddard et al., 2010; McKinney, 2002), and will become increasingly important as 68% of the world's population is projected to live in cities by 2050 (United Nations, 2018). Turf lawns are one of the dominant green spaces in urban areas and are estimated to cover ≈1.9% of the continental United States, predominately in urbanized areas (Milesi et al., 2005). Lawns are managed as monocultures or mixtures of turfgrass species, but can host a variety of flowering forbs and grasses that are often considered weeds. In the United States, these plants are predominantly of European origin (Lerman and Milam, 2016; Wheeler et al., 2017; Whitney, 1985).

With lawns dominating a large portion of urban landscapes and only likely to increase, they are a natural target for measures to improve biodiversity. In Paris, France, gardening practices have been designed and incentivized to increase biodiversity through a program known as the "differential management" program (Shwartz et al., 2013). This program aims to modify a number of common landscaping practices, such as decreasing the frequency of mowing and amount of pesticide use. An evaluation of the program found that gardens certified as "biodiversity friendly" housed a greater diversity of pollinators, birds, butterflies, and wild plants. Lawns in the differential management program housed 69% of wild flowering plants, demonstrating lawns can be significant sources of diversity in this urban system. Researchers in Reading, United Kingdom, developed floral lawns with no grass component that hosted high abundances of flower-visiting insects compared with regular turf (Smith et al., 2014).

Although redesigning lawns to support biodiversity in Europe has met with some success, one key way they differ from North American lawns is that most forbs in European lawns are considered native to the region: between 83% and 94% (Bertoncini et al., 2012; Thompson et al., 2004). In contrast, in North American lawns, only a minority of flowering species are native [Lerman and Milam (2016) report 30% of forbs found in lawns as native] and tend to be dominated by European species (Wheeler et al., 2017; Whitney, 1985), although this varies depending on location, climate, and management. European lawn flowers, such as white clover (*Trifolium repens*), attract a variety of insect visitors in U.S. landscapes (Larson et al., 2014), but native plants have been found to attract greater quantities and, in some cases, greater numbers of species than non-native flowers (Frankie et al., 2005; Pardee and Philpott, 2014; Smith et al., 2014), and strategies for increasing their presence in lawns would likely increase their ability to support biodiversity in North America. This is also a key challenge, as most North American native plants do not share the long pastoral history of Western Europe that likely shaped the evolution of these

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plants to tolerate repeated defoliation (Leffel and Gibson, 1973).

Repeated defoliation, in the form of mowing, seems to frequently impact the floral diversity of lawns, but in mixed ways. For lawns in Paris, there was no effect of mowing frequency on floral diversity, but higher mowing heights benefited floral richness in smaller home lawns, although not in large park lawns (Shwartz et al., 2013). In both the turfless floral lawns and conventional turf in Reading, United Kingdom, more intense mowing frequencies negatively impacted floral visitors, but floral richness was favored by intermediate mowing frequencies (Smith and Fellowes, 2014) where lawns were mowed to 4 cm when they attained 6 cm in height. One observational study in Paris found that mowing frequency, among other factors, negatively impacted plant diversity (Bertoncini et al., 2012). Conversely, another observational study of lawns in Sheffield, England, found that mowing frequency had little effect on plant richness (Thompson et al., 2004). In Saltdean, England, where mowing frequencies were experimentally controlled, an increase in both floral abundance and floral visitor abundance was observed under less intense mowing regimens (Garbuzov et al., 2014). In the United States, less frequent mowing was found to improve both floral resources and pollinator abundance and richness in suburban areas (Lerman et al., 2018). It seems clear that any effort to enhance lawns for biodiversity must consider how mowing affects the establishment and maintenance of forbs within lawns.

To increase the ability of lawns to support biodiversity in North America, we set out with the objective of identifying forb species and mowing practices that could be used during the establishment of a new lawn to achieve greater floral diversity and abundance. We targeted six native forbs with low growth habits and seed availability from commercial sources, and two non-native species that were commercially available, have a known value to bees, and are relatively noninvasive in natural areas. We tested if 1) interseeding these forbs at time of lawn establishment would result in establishment and bloom of target forbs, and 2) if mowing height would affect the ability of target forbs to establish and bloom in these same lawn plantings. Because native plants with low growing habits come from a variety of both moist and dry habitats, we chose two different locations for our study with different soil environments. One location was a "xeric site," with a well-drained sandy soil with limited organic matter, and the other a "mesic site" with loamy soil and high organic matter. We predicted that study locations would favor different species, and that higher mowing heights would generally aid the establishment and bloom of targeted forbs in both locations.

Materials and Methods

Site characteristics. Two study sites were established by dormant seeding in November of 2013 (late fall in Minnesota): one at the Turfgrass Research Outreach and Education Center (TROE) at the University of Minnesota St. Paul campus and the other at the University of Minnesota Sand Plains Research Farm (SPRF) located in Becker, MN. Both soil types are commonly found in the seven-county metro area of Minneapolis-Saint Paul. Aggregate soil samples were taken over the entire study area at each site. The TROE site was a silty clay loam (7.5% sand, 61.3% silt, 31.3% clay) with an organic matter content of 4.3% (Supplemental Table 1), with a soil profile designation of Kingsley sandy loam with a 2% to 6% slope. The SPRF site was a sandy clay loam (68.8% sand, 8.2% silt, and 22.5% clay) with an organic matter content of 1.7% (Supplemental Table 1) and a soil profile designation of Hubbard-Mosford complex with 0% to 3% slope. Sites were prepared for planting through an application of glyphosate, rototilling, and soil leveling to create an adequate soil bed.

Site climatic conditions varied slightly between sites during the April to September growing season. The TROE location averaged slightly higher monthly temperatures in 2014 through 2016 (Supplemental Table 2), being on average 0.9 °C warmer than the SPRF. Average monthly precipitation was higher at the SPRF in 2014 and 2015, averaging 2.1 cm and 1.1 cm more rain fall than TROE, respectively, but was higher at TROE in 2016 with an average of 3 cm more rain fall than the SPRF (Supplemental Table 2).

Species selection. Eight forb species were selected (Table 1) for coestablishment with turfgrass based on recommendations from local nursery growers, growth height characteristics, and perceived value as a forage plant for bees; that is, a flower that provides floral nectar or pollen for bee pollinators. Hard fescue (*Festuca brevipila*) was chosen as the companion turf species for its slow growth habit and low water and fertilizer input needs along with results from an earlier study showing its utility in a flowering lawn (Lane et al., 2019). Forb seed lots for each species were tested for germination in 2015 (Supplemental Table 3).

Site establishment. Dormant seeding was used due to multiple flower species having a cold stratification requirement for germination. Seeding of experimental plots occurred in November of 2013, and proceeded as follows: a broadcast seeding hard fescue at a rate of 171 $kg \cdot ha^{-1}$ N over the 0.26-ha area that all single-species forb plots would be seeded, then forb species were hand seeded into meter-square monospecies plots at a standardized rate of 241 seeds per plot. Surface seeding was chosen as our establishment method, as it is the most commonly used method for seeding new lawns. Monospecies plots were arranged in a randomized complete block design with five replicates, and two blocks of species per replicate. Each species block within a replicate was assigned either a low mowing height or a high mowing height treatment. This resulted in a total of 80 monospecies plots, with each species being replicated five times in the low mowing height and high mowing height treatment at both locations.

At time of seeding, a starter fertilizer application of Sustane (4N–1.76P–3.32K) was applied at the rate of 21 $kg \cdot ha^{-1}$ P (47.7 $kg \cdot ha^{-1}$ N and 39.6 $kg \cdot ha^{-1}$ K) at both locations. At the time of germination (16 June 2014), an additional slow-release fertilizer, was applied at 24.4 $kg \cdot ha^{-1}$ N (2.2 $kg \cdot ha^{-1}$ P and 12.2 $kg \cdot ha^{-1}$ K) using Sustane (15N–1.3P–7.5K). Due to excessive yellowing of grass blades in late spring at the SPRF location, we applied a slow-release fertilizer, Sustane (18N–0.44P–8.3K), at a rate of 201 $kg \cdot ha^{-1}$ N (5 $kg \cdot ha^{-1}$ P and 93 $kg \cdot ha^{-1}$ K) in July of 2014. In the following year, we again applied the same fertilizer treatment but at the rate of 43.6 $kg \cdot ha^{-1}$ N (1.1 $kg \cdot ha^{-1}$ P and 20 $kg \cdot ha^{-1}$ K). The SPRF location also was provided supplemental irrigation when dry conditions persisted and had a total of 17.8 cm and 22.2 cm of water applied in 2014 and 2015, respectively. No irrigation was provided in 2016. These additional inputs into the SPRF represent actions homeowners would and do take to establish turfgrass in challenging environments such as sandy soil. Plots were neither irrigated nor fertilized at either location in 2016.

Mowing height treatments. Blocks of plants in each replicate were assigned to two commonly used mowing heights in home lawns, with either a 6-cm (low mowing height) or 9-cm (high mowing height) treatment for the course of the study. In 2014 and 2015, mowing height treatments were maintained using a height-based criterion to initiate a mowing event, which proceeded as follows: 1) the height of the tallest vegetation in each monospecies plot was measured; 2) if any plot height exceeded its assigned height for its block by more than one-third (9.5 cm for the 6-cm treatment group and 11 cm for the 9-cm treatment group), all plots in that block were mowed their assigned treatment height. This scheme is based on the botanical principle in which no more than one-third of turf canopy should be pruned at a given time (Turgeon, 1999). Plot heights were surveyed frequently, from every 4 to 7 d based on growing conditions. This mowing scheme resulted in a fairly conservative mowing schedule that ranged between 3 and 4 and 5 and 7 mowing events per growing season for the SPRF and TROE locations, respectively. Our mowing scheme allowed for mowing treatments to be mowed at different frequencies (i.e., if mowing height effected growth rate), but both treatments grew at relatively the same rate and were mowed together. The SPRF location received fewer mowing treatments because of slower growth rates, presumably due to nutrient and water limitations imposed by the low organic matter content and the high proportions of sand in the soil.

In 2016, plots were mowed on a timed schedule due to logistical constraints. Each site was mowed approximately once per

Table 1. List of forb species used and their properties extracted from online databases.

Species	Common name	Ht (cm)	Habitat	Bloom time
Anemone patens (L.) Mill.	Pasque flower	7.6–45.7	Dry–sunny	April–May
Claytonia virginica L.	Spring beauty	7.6–12.7	Moist–shady	April–June
Oxytropis lambertii Pursh	Purple locoweed	10.2–40.6	Dry–sunny	April–June
Astragalus crassicarpus Nutt.	Ground plum	10.2–61	Dry–sunny	May–June
Erigeron compositus Pursh	Cutleaf daisy	15.2	Dry–sunny	May–July
Trifolium repens L.	Dutch white clover	20.3	Moist–sunny	June–October
Prunella vulgaris ssp. *lanceolata* (W. Bartram) Hultén	Lanceleaf selfheal	7.6–30.5	Moist–sunny	June–August
Thymus serpyllum L.	Creeping thyme	20.32	Dry–sunny	July–September

Table 2. Type III analysis of variance results from the linear mixed-effects model for each forb's leafing and flowering units with interactions.

Factor	Degrees of freedom	χ^2	*P* value
Trifolium repens			
Trifoliate leaves:			
Mowing height	1	0.16	0.68
Location	1	4.38	0.036[z]
Mowing height × Location	1	0.5	0.48
Blooms:			
Location	1	0.25	0.6
Mowing height	1	0.51	0.48
Location × Mowing height	1	1.1	0.31
Prunella vulgaris			
Basal rosettes:			
Mowing height	1	0.16	0.68
Location	1	44	<0.001[z]
Mowing height × Location	1	0.1	0.78
Blooms at Turf Research, Outreach, and Extension center:			
Year	2	10.4	<0.001[z]
Mowing height	1	6.3	0.01[z]
Year × Mowing height	2	2.3	0.33
Blooms at Sand Plains Research Farm:			
Mowing height	1	2.5	0.12
Thymus serpyllum			
Stems:			
Mowing height	1	1.8	0.2
Location	1	6.1	0.01[z]
Mowing height × Location	1	1.9	0.17
Blooms 2016:			
Mowing height	1	0.46	0.5
Astragalus crassicarpus			
Stems:			
Mowing height	1	0.01	0.9

[z]Denotes significant result.

month, which resulted in three mowing events at SPRF and two mowing events at TROE. Although the timing of mowing events in 2016 differed from what was seen in 2014 and 2015, the assignment mowing heights to each block (6 cm vs. 9 cm) was consistent for each year of data collection.

Vegetation data collection. To assess establishment, we collected vegetative data from all plots for all species in September of 2014 and 2015. The number of plants establishing in plots can be difficult to determine for species with spreading vegetation, so aboveground vegetative units appropriate for the species were quantified on the premise it would correlate to the number of individuals establishing in a plot. This method has been most commonly applied for *T. repens* in the form of trifoliate leaves (McCurdy et al., 2013; Sparks et al., 2015), and was adopted here for additional species. Vegetative units were considered any structure that arose from the ground and could be reasonably counted over the entire plot. In addition to trifoliate leaves, these structures included basal rosettes (*P. vulgaris*) and stems (*T. serpyllum* and *A. crassicarpus*). These data were collected before a final mowing event in September to avoid introducing a cutting bias in the data. Vegetative structures were not quantified in 2016 because of limited resources.

Bloom data collection. Because each species in this study has a different flowering phenology, plots were surveyed for the onset of flowering every 4 to 7 d, concurrently with plot height measurements. If flowering was detected for any species, blooms within a plot were counted for all plots of that species at that location before mowing. This resulted in a quantification of blooms every 4 to 7 d once flowering began and until flowering had ceased. Data for each forb species was considered separately during analysis, and only once blooming had begun at that location. A bloom was counted only if it contained at least one unsenesced floret.

In 2016, bloom data were collected differently, with plots receiving overall less management. The first data collection point at SPRF occurred in May to measure the bloom of *A. crassicarpus*, a species that was able to establish only under the sandy soil conditions at SPRF. After this collection point, blooms were measured once per month at each location culminating in a final data collection in late July/early August. Data collection ended in early August based on the phenology of the flowers established in the plots.

Analysis. All analyses were conducted in the R statistical environment (R Core Team, 2019). First, a mixed-effects model was specified using the "*nlme*" package (Pinheiro et al., 2018) with either vegetative units or blooms for each species as a response variable and location × treatment as a fixed effect. Plot number was specified as a random effect to account for repeated measures of plots over the growing season (in the case of blooms) and year. Model assumptions of homoscedasticity and normality were evaluated by inspection of residual plots. If assumptions were violated, square root transformations were applied and residual plots reevaluated. If assumptions were still not met through square root transformations, a log transformation was applied and residual plots were reevaluated. In all cases, transformations were sufficient to accommodate model assumptions. All figures represent the untransformed data. We then specified a type III analysis of variance (ANOVA) using the "car" package (Fox and Weisberg, 2011) for each mixed-effects model to determine if fixed effects and their interaction were significant. Analyses were conducted only for species with sufficient data across locations and/or treatments. Although our model accounted for variation through time, we chose to use year as a fixed effect for blooms of *P. vulgaris*. We did this because it was one of the few species we had bloom data for in all 3 years for a location, and also to highlight a significant trend over time for this species. We also evaluated bloom for *P. vulgaris* separately for both locations, as the TROE location had 3 years of bloom data, whereas SPRF achieved bloom only in the final year.

In cases in which there were significant effects were found, a "Tukey" means separation protocol for pairwise comparisons using the "*multcomp*" package (Hothorn et al., 2008) was used to assess differences between treatments or locations.

Results

Forb establishment. Of the eight species investigated in our trials, we saw establishment and bloom for four species: *T. repens*, *P. vulgaris*, *T. serpyllum*, and *A. crassicarpus*. Both *T. repens* and *P. vulgaris* bloomed

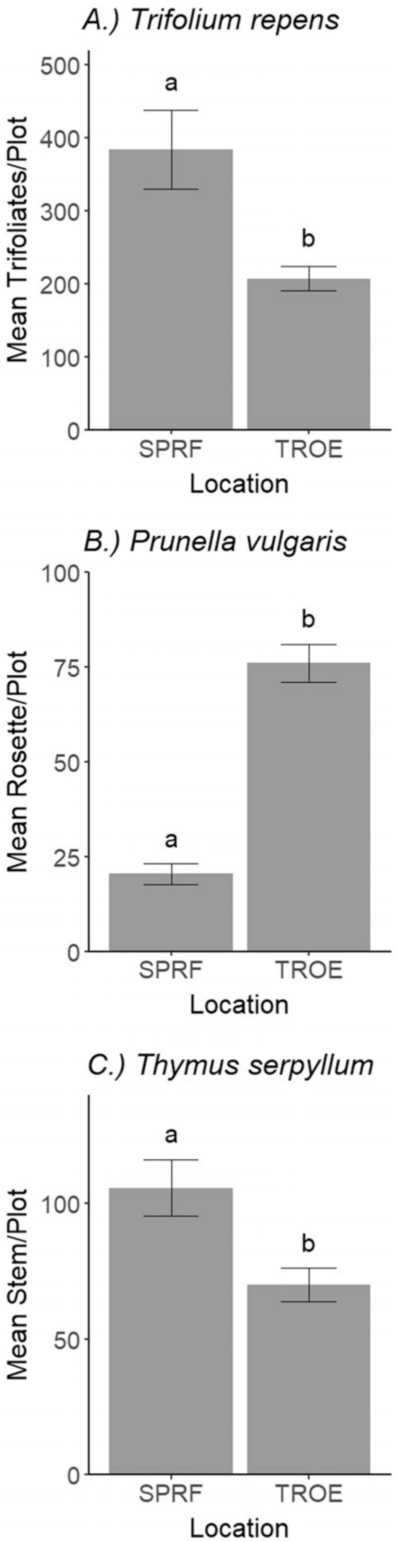

Fig. 1. Number of mean vegetative structures per plot for *Trifolium repens* (**A**), *Prunella vulgaris* (**B**), and *Thymus serpyllum* (**C**) at the location with fine-textured soil and high organic matter (TROE) and the site with high sand content in soil and low organic matter (SPRF). Error bars represent standard error of the mean and letters denote a significant difference as determined by Tukey's mean comparison with an $\alpha = 0.05$.

during the first growing season, with *T. serpyllum* achieving bloom at both sites by the third year. Although *A. crassicarpus* established only at the SPRF location, it achieved bloom in some plots by the third year as well. We saw no evidence of vegetative establishment or blooms of the remaining four species: *Claytonia virginica*, *Anemone patens*, *Oxytropis lambertii*, or *Erigeron compositus*.

Vegetation response to mowing height and location. Results from ANOVA of mixed-effects models indicated that none of the observed forb vegetation showed a significant interaction between mowing treatment and location, or between mowing treatments within location, indicating that mowing did not seem to affect the growth/development of vegetative structures of forb species we observed (Table 2).

Location, however, was significant for three of the observed forbs. Trifoliate leaf counts of *T. repens* were significantly higher at SPRF (385 mean trifoliates per plot) compared with the TROE location (208 mean trifoliates per plot) (Fig. 1A). The reverse was true for counts of *P. vulgaris* basal rosettes, which were significantly higher at TROE (76 mean rosettes per plot) compared with the SPRF location (20 mean rosettes per plot) (Fig. 2B). Similar to *T. repens*, *T. serpyllum* had significantly higher vegetative growth at the SPRF with 105.8 mean stems per plot compared with TROE with 70 mean stems per plot (Fig. 1C). Leafing units of *A. crassicarpus* were found only at the SPRF location (3.25 mean stems per plot), and were not significantly different between mowing height treatments (Table 2).

Bloom response to mowing height and location. Of the four species found blooming in our trials, *T. repens* was the only species to bloom at both locations in every year. Analysis indicated there were no differences in mean blooms per plot in either location or mowing treatment (Table 2). *P. vulgaris* blooms were found only at the TROE site in 2014 and 2015, but were found at both sites in 2016. As such, we analyzed these data separately for both TROE and SPRF due to unequal sampling across years. We found a significant effect of mowing height at the TROE location [$F_{(1,18)} = 6.2$, $P = 0.02$] with low mowing heights having lower mean rosettes per plot (4.6 mean blooms per plot, $P = 0.01$) than in high mowing height plots (10.6 mean blooms per plot, Fig. 2A). Because of a noticeable decline in *P. vulgaris* blooms after the first year, we tested for a mowing height × year interaction at the TROE location. We found a significant effect of year [$F_{(2,26)} = 10.4$, $P \leq 0.001$], but we found no evidence of an interaction [$F_{(2,26)} = 1.1$, $P = 0.34$]. Means comparisons for blooms over years revealed an initial burst of flowering in 2014, averaging 17.4 mean blooms per plot, followed by a steep decline in 2015 that was sustained in 2016 (averaging 5.8 and 4.4 mean blooms per plot, respectively, Fig. 3). This initial bloom was significantly higher than in both 2015 and 2016 ($P \leq 0.01$ for both years), but 2015 and 2016 did not differ from each other ($P = 0.7$).

T. serpyllum blooms were found only at the SPRF location in 2015 in 3 of 10 plots during the course of its bloom season, and only in plots mowed at the 9-cm mowing height. As a result, means comparisons for location and mowing height were not appropriate. Conversely, in 2016, the TROE location had a significant amount of *T. serpyllum* bloom (every plot had blooms), whereas the SPRF location had only a single plot with blooms. Because of the negligible bloom at SPRF, mowing height comparisons for this species were done only for the TROE location. Bloom counts were 10.6 per plot in the high mowing height treatment compared with four per plot in the low mowing height treatment; this relationship was not significant [$F_{(1,8)} = 0.5$, $P = 0.54$, Fig. 2B].

Two *A. crassicarpus* blooms were observed in one plot at the SPRF location in 2015, and in 2016 three plots at SPRF were found to have blooms, with 2, 12, and 25 blooms for each plot. The small number of plots in which blooms occurred made statistical analysis inappropriate, but these results show that this species has the potential to establish and bloom in lawns, if only sporadically.

Discussion

This study represents an important first step in identifying forbs and management practices that could be applied in the diversification of lawns for the purpose of pollinator conservation. Of the eight forbs we investigated, four of them established and bloomed, with location and mowing height treatments playing a mixed role for each species.

Location played a prominent role in the vegetative establishment of all species observed, with *T. repens*, *P. vulgaris*, *T. serpyllum*, and *A. crassicarpus* all showing differences in vegetative growth between locations. The location with high soil sand content (SPRF) favored *T. repens*, *T. serpyllum*, and *A. crassicarpus*. *T. repens* established well at both sites and is well known for its adaption to a wide range of soil conditions (Turkington and Burdon, 1983). Its increased vegetative growth at the SPRF may be due to nitrogen limitation (as evidenced by yellowing of grass leaves) imparting a competitive advantage for the species over its companion grass due to the ability of *T. repens* to fix nitrogen. To our knowledge, no studies on the optimal establishment and site conditions for *P. vulgaris* or *T. serpyllum* have been conducted, although reports of optimal growing conditions exist. The U.S. Natural Resource Conservation Service reports that *P. vulgaris* prefers moist and disturbed conditions across a wide range of habitats (Young-Mathews, 2012), suggesting that the low moisture retention of sandy soils may not favor its growth. Studies on the distribution of *T. serpyllum* suggest that it is most commonly found in dry and human disturbed areas,

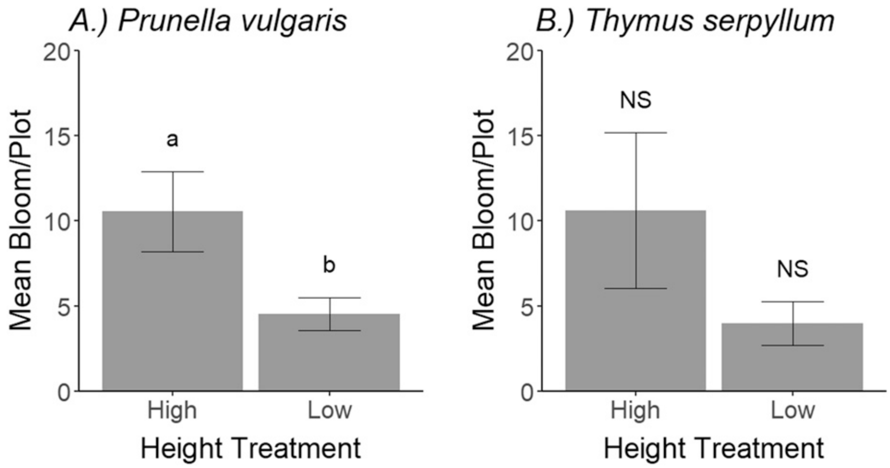

Fig. 2. Number of mean blooms per plot for *Prunella vulgaris* (**A**) and *Thymus serpyllum* (**B**) in treatments with a higher mowing regimen (9 cm) and the lower mowing regimen (6 cm). Error bars represent standard error of the mean and letters denote a significant difference as determined by Tukey's mean comparison with an $\alpha = 0.05$.

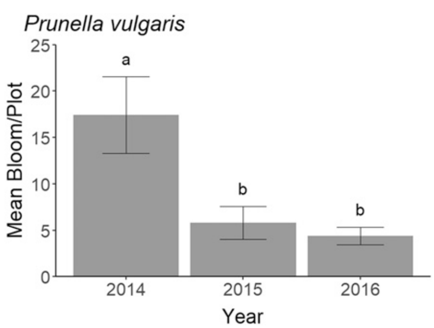

Fig. 3. Number of mean blooms per plot for *Prunella vulgaris* in the 3 years of floral data collection at the TROE site. Error bars represent standard error of the mean and letters denote a significant difference as determined by Tukey's mean comparison with an $\alpha = 0.05$.

although it can tolerate mesic conditions as well (Eriksson, 1998). This preference for drier conditions may have played a part in its success at the SPRF location.

Location also affected the bloom of some species. *P. vulgaris* blooming was delayed at the SPRF until 2016, and then achieved only a relatively low level of one mean bloom per plot compared with the TROE location, which achieved 7.6 mean blooms per plot in the same year. *T. serpyllum* achieved its highest level of bloom in 2016 at TROE, counter to the 2014–15 trend for higher stem counts at the SPRF. Because we ceased any supplemental inputs (such as water and nutrients) at the SPRF location that year, it is difficult to determine if the SPRF location became less favorable during this time, or if the TROE location establishment was delayed. From other studies we have conducted with *T. serpyllum*, we have observed that, although *T. serpyllum* seems slow to establish, it does well in mesic lawn environments, such as at TROE. This is also supported by other observations of lawn environments (Eriksson, 1998; Stalter et al., 1993).

Mowing height had a negligible role on vegetative establishment at both sites and had no impact on the flowering of observed species except for a consistent negative effect on *P. vulgaris* in the low mowing height treatment at TROE. This is somewhat supported by previous work that investigated mowing frequency effects on turfless lawn, where *P. vulgaris* coverage was affected by mowing frequency (Smith and Fellowes, 2014). The lack of negative effect of mowing height was surprising given previous studies finding negative effects of mowing frequency and height on lawn forbs (Bertoncini et al., 2012; Garbuzov et al., 2014; Lerman et al., 2018). One possible explanation is due to the relatively low frequency with which our cutting treatments were applied. Because we used a height-based mowing criterion combined with the slow-growing grass *F. brevipilla*, the number of mowing events was much lower compared with other studies. This is somewhat encouraging, as our results suggest combining slow-growing turfgrass with height-based mowing regimens reduces mowing pressure on turf swards and thus the potential negative effects of mowing on forbs. Previous research has shown that turf species can affect forb flowering (Lane et al., 2019), regardless of mowing regimen, and is an important consideration in crafting floral lawns. Regardless of low mowing frequency, *P. vulgaris* still saw negative impacts on bloom at the low mowing height, highlighting that some species may be more sensitive than others to mowing regimen during bloom.

Four of the eight species, *C. virginica*, *A. patens*, *O. lambertii*, and *E. compositus,* did not establish in our research plots. Their failure to establish in plots could be for a number of reasons, such as germination challenges and environmental mismatches. When we conducted germination tests in a growth chamber for the selected species, the nonestablishing species either did not germinate at all (*E. compositus*) or only sparsely (*C. virginica*, *A. patens*, *O. lambertii*) (S2). This lack of germination indicates that there may be additional dormancy mechanisms, germination requirements, or planting strategies needed beyond cold stratification. *C. virginica*, for example, has been known to establish in lawns (Schemske et al., 1978), but is typically found in more shaded environments where its seeds are stored underground by ants. This may indicate an important biotic interaction our research plots were unable to re-create. *A. patens* also has been found in association with close grazing and mowing (Wildeman and Steeves, 1982), but previously documented low germination rates (Greene and Curtis, 1950) indicate other dormancy breaking requirements may have been poorly met by our study design. These challenges could be overcome through additional seed treatments, or transplanting individuals directly into lawns. Previous work has seen some success in the transplanting of *C. virginica,* and other species, directly into warm-season lawns (Wisdom, 2018).

Another possible explanation for why these species failed to establish is that our growing sites were poor matches for their environmental needs. *O. lambertii* is a low-growing forb but is more characteristic in dry environments (Wheeler et al., 1992; Whitman and Stevens, 1952). *E. compositus*, although a native to the central United States, is more characteristic of rocky sites in montane habitats very different from our planting sites. We believed that the low growth habit and a well-drained soil (such as at SPRF) would allow these species to germinate and persist given the slow-growing turf companion species, but the increased inputs and mowing may have excluded them.

Overall, these results are encouraging and indicate that forbs can establish and bloom, especially *T. repens, P. vulgaris*, *T. serpyllum*, and *A. crassicarpus*, when seeded concurrently with *F. brevipilla*. Future efforts to diversify lawns would benefit from expanded species exploration using both seed and transplanted individuals. One of the largest barriers to implementing flowering lawns with native forbs is a lack of seed stock available from local nurseries. Many native plants have low-growing traits that are desirable for forbs in turfgrass plantings, such as low and competitive growth habits, but seeds are not available in appreciable quantities. This lack of seed stock is potentially due to the difficulty in harvesting plant seeds from low-growing plants, as well as a lack of demand from the public for plants with these qualities. Future directions with flowering lawns using native plants should seek partners in the native plant seed industry to facilitate the exploration and production of candidate plant seeds for use in research and by the public.

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Supplemental Table 1. Soil fertility and texture results from the Turf Research, Outreach, and Extension Center (TROE) and the Sand Plains Research Farm (SPRF).

Name	Bray P (ppm)	NH_4OAc-K (ppm)	Organic matter (%)	Water pH	Sand (%)	Silt (%)	Clay (%)
TROE	61	149	4.3	6.1	7.4	61.3	31.3
SPRF	39	53	1.7	6.6	68.8	8.7	22.5

Supplemental Table 2. Mean temperature and precipitation for each month of the growing season, at the Turf Research, Outreach, and Extension center (TROE) and the Sand Plains Research Farm (SPRF).

Month	Location	Yr	Mean temp (°C)	Mean precipitation (cm)
April	SPRF	2014	4.5	13.97
April	SPRF	2015	8.4	4.7
April	SPRF	2016	7.3	5
April	TROE	2014	4.6	17.6
April	TROE	2015	8.5	5.3
April	TROE	2016	7.7	9.3
May	SPRF	2014	13.6	22
May	SPRF	2015	13.6	14.5
May	SPRF	2016	14.3	6.7
May	TROE	2014	13.8	9
May	TROE	2015	13.8	12.5
May	TROE	2016	14.8	5.2
June	SPRF	2014	19.1	21.6
June	SPRF	2015	18.9	8.7
June	SPRF	2016	19.3	6.4
June	TROE	2014	21.1	23.4
June	TROE	2015	19.8	8.4
June	TROE	2016	20.4	9.3
July	SPRF	2014	19.9	5.3
July	SPRF	2015	21.1	18.6
July	SPRF	2016	21	16.5
July	TROE	2014	21.8	6.9
July	TROE	2015	21.9	15.7
July	TROE	2016	22.5	15.2
August	SPRF	2014	20.3	10.6
August	SPRF	2015	19.5	14.8
August	SPRF	2016	20.6	11.7
August	TROE	2014	22.2	7.9
August	TROE	2015	20.1	7.1
August	TROE	2016	21.4	25.1
September	SPRF	2014	15.4	9.8
September	SPRF	2015	18.2	4.1
September	SPRF	2016	16.4	12.9
September	TROE	2014	16.1	5.6
September	TROE	2015	18.8	9.7
September	TROE	2016	17.5	13.2

Supplemental Table 3. Seed germination testing seeds for each species were separated into three replicates of 30 seeds. Seeds were subjected to 60 d of 1.5 °C for cold stratification, then placed in a growth chamber in petri dishes with germination paper. Petri dishes were checked daily to ensure adequate moisture. After 14 d, initial germination was checked (7 Nov.), and germination was recorded. Germinated seeds were removed, and remaining seeds were checked on 25 Nov. Data were averaged for each species.

Species	Germination (%)
Trifolium repens	89
Thymus serpyllum	61
Anemone patens	2
Prunella vulgaris	72
Erigeron compositus	0
Astragalus crassicarpus	4
Oxytropis lambertii	3
Claytonia virginica	3

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Turfgrass Species Affect the Establishment and Bloom of Kura Clover (*Trifolium ambiguum*) in Lawns

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***Abstract*. Lawns represent one of the largest cultivated areas in urban landscapes, and in the Upper Midwest of the United States, lawns are typically composed of a small number of cool-season turfgrass species. There is increased interest in enhancing areas dedicated to lawns using flowering species for conservation purposes—for example, to support pollinators. In this study we used a model flowering forb, Kura clover (*Trifolium ambiguum* M. Bieb.), because—like many flowering species of conservation interest—it is slow to establish and is sensitive to grass competition. We varied the Kura clover seeding rate into four different turfgrass species treatments: kentucky bluegrass (*Poa pratensis* L.), hard fescue (*Festuca brevipila* Tracy), tall fescue [*Schedonorus arundinaceum* (Schreb.) Darbysh.], and perennial ryegrass (*Lolium perenne* L.) in two separate trials. Establishment and bloom of Kura clover was significantly greater in trial 1 for kentucky bluegrass and hard fescue than tall fescue and perennial ryegrass. In trial 2, Kura clover established significantly greater in kentucky bluegrass compared with tall fescue and perennial ryegrass, whereas Kura establishment in hard fescue was not significantly different from the other treatments. The seeding rate of Kura clover did not affect establishment in either trial. The results from this study suggest kentucky bluegrass and hard fescue are promising turf companion grasses for future forb/turf interseeding research.**

Turf lawns are estimated to cover roughly 2% of the continental United States (Milesi et al., 2005), mostly in highly urban areas. Although management of lawns varies by function and individual manager, it is typically characterized by three primary cultural practices: mowing, fertilizing, and irrigation (Turgeon, 1999). These practices are intended to favor turf species and, when applied in tandem with proper establishment techniques, result in stands of uniform turf. Despite lawns being currently managed as uniform monocultures, they are often host to flowering plants that provide foraging resources for bees and other pollinators. A recent insect survey of park lawns hosting dandelion (*Taraxacum officinale* F.H. Wigg.) and white clover (*Trifolium repens* L.) conducted in Lexington, Kentucky (Larson et al., 2014), found 37 associated bee species. These plant species are typically considered weeds in the United States and are sometimes eliminated through the use of broadleaf herbicides. However, lawns managed intentionally for forb abundance and richness would likely have a beneficial impact to local foraging bee communities. Previous research has suggested a strong positive relationship between forb community richness and pollinator community richness that likely extends to lawn communities as well (Ebeling et al., 2008; Potts et al., 2003). Such management goals would necessitate the reduction of other lawn inputs and would further the goal of increased sustainability. Mowing often correlates negatively with plant species richness in lawns (Bertoncini et al., 2012; Garbuzov et al., 2014; Lerman et al., 2018; Shwartz et al., 2013; Smith and Fellowes, 2015), and managing floral lawns could lead to less-intensive mowing regimes. The inclusion of legumes such as white clover has shown to enhance turf nitrogen uptake through nitrogen fixation (McCurdy et al., 2014; Sincik and Acikgoz, 2007), and would potentially reduce fertilizer inputs into lawns.

At the other extreme of flowering lawns, researchers as the University of Reading in the United Kingdom have abandoned the use of turfgrasses altogether, and have been developing species lists and management practice guidelines for purely floral lawns (Smith and Fellowes, 2015) that have been found to have benefits to flower-visiting insects (Smith et al., 2014). These lawns may provide benefits to flower-visiting insects, but they are not meant to be areas of high human traffic and recreation. Human traffic on monocultures of white clover was found to reduce green cover up to 14 times faster when compared with hybrid bermudagrass [*Cynodon transvaalensis* Burtt-Davy 3 *C. dactylon* (L.) Pers.], suggesting the importance in turfgrasses for maintaining long-term cover in variable traffic conditions (Brosnan et al., 2014). Another potential challenge of these nonturfgrass plantings is the reliance on precultivation and installation, which can be costly on a large scale, and the potential need for more specialized care. In addition, there is still a strong cultural connection with turf lawns (Harris et al., 2013), and an intermediate flowering lawn that combines turfgrass and floral species may have broader and more practical appeal, especially for recreational use. For these reasons, grass–forb mixes established from seed are an important area of focus for future research. This type of floral-enhanced lawn should provide quick groundcover, reduce lawn maintenance, save money, and provide typical lawn functions such as recreation.

Although floral lawns hold great promise in improving biodiversity in urban areas, guidelines for establishing usable forbs in a lawn are needed to encourage adoption. The main objective of this study was to identify a turfgrass species that would allow for better success in the introduction of flowers not typically thought of as turf weeds. An ideal turfgrass species would maintain groundcover, but also allow for establishment and bloom of its forb companions. Some effort has been made into developing seeding strategies for white clover into established lawns to benefit pollinators and soil nitrogen (McCurdy et al., 2013; Sparks et al., 2015). White clover is an established agronomic crop that is widely associated with pasture agriculture, and is well adapted to the grazing systems under which it evolved (Leffel and Gibson, 1973). Pasture systems and lawns are similar in many ways, (e.g., compaction and cutting by animals or humans) and it is no surprise that white clover does well in both environments. So although white clover is a viable option for improving lawn floral abundance, more forb options are needed to improve the diversity and conservation value of turfgrass lawns.

To understand more fully how turfgrass species influence other forbs, we selected four common turfgrass species used in home lawns in the northern United States to mix with a species of clover: Kura clover

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(*Trifolium ambiguum* M. Bieb.). Kura clover is a rhizomatous perennial plant originating from eastern Europe/western Asia and has been investigated as a cold-tolerant forage plant for pasture cattle in the United States. Kura clover is not commonly cultivated across the United States, but it can be found growing infrequently in seminatural areas. Kura clover is known for its slow establishment period and sensitivity to grass competition (Hill and Mulcahy, 1995; Seguin et al., 1999) when used under pasture conditions. Kura clover's agronomic properties, such as high seed germination rates and grazing tolerance, combined with its sensitivity to competition make it an ideal model species for isolating how competitive pressure from different turf species might affect the establishment and bloom of flowering plants not typically associated with turfgrass lawns.

We predicted that slow-establishing and nonrhizomatous turf species would favor Kura clover establishment and bloom, whereas fast-establishing and rhizomatous species would disfavor Kura establishment and bloom. Our primary goal was to identify turfgrass species that can be seeded at their recommended rates while minimizing turfgrass species-specific competitive effects. Identifying turfgrass species more amenable to forb species additions is important to subsequent studies aimed at identifying other limiting factors in forb establishment, such as germination and mowing tolerance. This is the first of a series of studies that aims to provide foraging resources for pollinating insects in turf lawns.

Materials and Methods

Species selection. We selected four commonly used cool-season turfgrasses: 'Moonlight SLT' kentucky bluegrass (*Poa pratensis* L.), 'Beacon' hard fescue (*Festuca brevipila* Tracy), 'Grande II' tall fescue [*Schedonorus arundinaceum* (Schreb.) Darbysh.], and 'Apple GL' perennial ryegrass (*Lolium perenne* L.). Hard fescue is a slow-establishing turfgrass species with a bunch-type growth habit. Of the four species selected, we predicted Kura clover to establish and bloom at its highest rate in hard fescue stands. Kentucky bluegrass is a slow-establishing turfgrass species with a rhizomatous growth habit that we predicted to have intermediate levels of Kura clover establishment and bloom. Both perennial ryegrass and tall fescue are commonly known for their ability to establish from seed rapidly, and we predicted the lowest establishment and bloom levels in plots established with these species.

Although seeding guidelines do exist for Kura clover establishment in grass pasture systems (Hill and Mulcahy, 1995; Vandevender, 2003), we chose to manipulate seeding rate because turfgrass systems may change stand quality dynamics. We chose to investigate both the lowest and highest recommendations for seeding: 0.57 and 1.1 $g \cdot m^{-2}$, respectively; as well as an intermediate rate of 0.85 $g \cdot m^{-2}$.

Experimental design and establishment. This study was conducted at the Turfgrass Research, Outreach, and Education Center (TROE) on the University of Minnesota St. Paul campus (lat. 44.9944, long. 93.1849). The soil at the TROE center is dominated by a Waukegan silt loam, which is a deep, well-drained soil with a fine silty top layer over a sandy bottom layer. Two trials were conducted, with the first starting in 2013 and the second in 2014. Both trials were in separate but adjacent plots. Aggregate soil samples were collected at the conclusion of the trials to characterize the soil environment through standard soil testing at the University of Minnesota Soil Testing Laboratory. The soil measurements for phosphorous, potassium, and soil organic matter were nearly identical in the two trials, with the exception of pH (trial 1 pH, 6.5; trial 2 pH, 6.1). Exact soil nutrient and organic matter values can be found in Supplemental Table 1. Trials were organized as a complete random factorial design, with four grass species and three Kura clover seeding rates as experimental factors. Each grass–seeding rate combination was replicated three times for a total of 36 observational units per trial, and combinations were arranged randomly into a six-plot × six-plot grid. Individual plot dimensions were 1 × 1.5 m, and each plot was separated by a 0.15-m border.

The first trial was seeded on 20 June 2013 and the second on 2 July 2014. Temperatures during the first month of establishment averaged a high of 29.5 °C and a low of 20.2 °C for trial 1, and a high of 27.2 °C and a low of 16.3 °C during the first month of trial 2. Sites were prepared by applying glyphosate to clear undesirable plants, rototilling to break up rooting structures, and power raking directly before seeding. Grass species were seeded at rates recommended by Turgeon (1999) (Table 1). Kura clover seeding rate treatments were 0.57, 0.85, and 1.1 $g \cdot m^{-2}$. Grass seed and Kura clover were both hand-seeded concurrently but from separate packets, with short barriers placed around the plot perimeter to prevent seeds from being blown outside the plot area. Because of the variable nature of Kura rhizobium nodulation (Beauregard et al., 2003; Laberge et al., 2005; Seguin et al., 2001), we made the decision not to inoculate at the time of seeding; in addition, we were using Kura as a model for other flowering plants and were not interested in highly successful Kura establishment. Rather, we wanted to observe how the species was affected by competition from common turfgrass species.

Starter fertilizer is a common recommendation for the establishment of new lawns, thus the trial area was given an application of EC Grow Greens Grade Fertilizer (EC grow Inc., Eau Claire, WN) (analysis 10N–7.9P–18.3K) directly after seeding, broadcast-applied at a rate of 3 g N/m^2. The study area was then covered with biodegradable Futerra® EnviroNet (PROFILE products LLC, Buffalo Grove, IL) blankets to prevent seed movement between plots; this type of blanket is sometimes used for lawn establishment, especially on sloped sites to prevent soil erosion. Plots were irrigated twice daily for 20 min during the first 2 weeks to assist establishment. Plots were mowed adhering to the one-third rule, mowing to an 8-cm height if any plot was at least 11 cm in height. Grass clippings were left onsite. Mowing practice and the nonremoval of grass clippings were meant to simulate best management recommendations for low-input turf lawns as provided by the University of Minnesota Extension Service. Data collection began in June of the year following seeding.

Data collection and analysis. Data were collected once per month for 3 months starting in June for each trial, and always preceded a mowing event to avoid introducing a cutting bias on plant metrics. A 1 × 1.5-m quadrat with nylon wire grid lines was used to help break plots visually into 117 12-cm^2 sections to facilitate the counting of Kura clover trifoliate leaves and blooms, which were summed over the entire plot, thereby providing an absolute abundance of trifoliate leaves and blooms. To estimate the percentage of total plot area covered by Kura clover leaves (leaf cover), recorders visualized the number of grid squares covered by Kura leaves as if in one contiguous patch and then divided that number by 117 (the total number of squares in the quadrat). To help control for the qualitative nature of this cover estimate, the leaf cover for a given plot was estimated by two observers and then averaged between them to obtain the final leaf cover number.

Fixed effects used to measure the establishment of Kura clover included trifoliate leaf count, bloom number, and plot leaf coverage. Data were analyzed with the R statistical program (v3.2.3; R core team, Vienna, Austria) using the nlme and multcomp packages. All three fixed effects were first tested for correlation with one another using Pearson's product-moment correlation coefficient. Initial analysis used an analysis of variance of a linear mixed-effects model (except in the case of blooms), in which Kura clover seeding rate and turf species were specified as an interaction term, and trial was an additive term. Because trial was significant in this first model, further analysis focused on each trial individually, keeping turf species and Kura seeding rate as an interaction term. Plot number was used as a

Table 1. List of turfgrass species used and their recommended seeding rate.

Species	Growth habit	Seeding rate ($g \cdot m^{-2}$)	Seeds/m^2
Poa pratensis	Rhizomes	6.8	32,225
Festuca brevipila	Bunch type	22.7	28,275
Festuca arundinaceae	Bunch type/short rhizomes	27.2	14,513
Lolium perenne	Bunch type	27.2	14,811

random effect to account for repeated measures throughout the sampling season, and a Tukey means separation protocol was used if *F* statistics were less than or equal to $\alpha = 0.05$ to test for significant differences among factor levels. The bloom response variable was analyzed with a linear regression model without mixed effects as a result of the blooms occurring only during one time point in the year (July). Assumptions of homoscedasticity and normality were verified by inspection of residual plots. Square root transformations were sufficient to meet assumptions for all analyses except for the bloom response variable in trial 1, in which case a log transformation was used.

Results

Trifoliate leaf count and percent cover of Kura clover were highly correlated (r = 0.937, $t_{(214)}$ = 39.2607, P < 0.001), so only trifoliate leaf counts were used in the analysis as a result of the qualitative nature of the leaf cover measurement. The relationship between trifoliate leaves and bloom number was strong (r = 0.712, $t_{(70)}$ = 8.4764, P < 0.001), indicating trifoliate leaf count is a good predictor of bloom count.

As result of the significant effect of trial in our initial model, trials were analyzed separately. In both trials, turf species affected significantly the numbers of trifoliate leaves and blooms ($P \leq 0.05$) (Table 2.). The seeding rate of Kura clover did not affect leaf or bloom counts significantly in both trials, and no significant interaction between turf species and seeding rate was detected. Hence, all pairwise comparisons between trifoliate leaves and blooms in different grass treatments were averaged over Kura clover seeding rate.

Trial 1. The average number of Kura clover trifoliate leaves in kentucky bluegrass (μ = 352) and hard fescue (μ = 365) plots were significantly greater than in both tall fescue (μ = 132) and perennial ryegrass (μ = 151) plots (Fig. 1A). This pattern was similar for the average number of blooms in the plots, with kentucky bluegrass (μ = 24) and hard fescue (μ = 26) both having significantly greater average Kura clover bloom counts than tall fescue (μ = 3) and perennial ryegrass (μ = 2).

Trial 2. The average number of trifoliate leaves and blooms in kentucky bluegrass plots (μ = 121 and 17, respectively) were significantly greater than average trifoliate leaf and bloom count in both tall fescue (μ= 57 and 3, respectively) and perennial ryegrass plots (μ = 63 and 4, respectively) (Fig. 1B). Unlike trial 1, hard fescue had intermediate numbers of average trifoliate leave and bloom counts (μ = 91 and 11, respectively), and was not significantly different from perennial ryegrass, tall fescue, or kentucky bluegrass.

Discussion

Kura clover establishment and bloom were affected by turfgrass companion species but were unaffected by seeding rate. Establishment and bloom were greatest in kentucky bluegrass when compared with tall fescue and perennial ryegrass, despite the differences in establishment between years. Kura clover tended to have greater establishment and bloom abundance in hard fescue than in perennial ryegrass or tall fescue, but was only statistically greater in the first year.

The well-known slow establishment rate of kentucky bluegrass (Christians et al., 2017) may have contributed to this result; the cultivar we used in this study, 'Moonlight SLT', exhibits poor seedling vigor compared with other kentucky bluegrass cultivars (Morris, 2016). Another factor that may have contributed to the greater establishment of Kura clover in kentucky bluegrass was the limited fertilizer regime used in our study. A previous study from Wisconsin found kentucky bluegrass stands to be especially weed prone compared with other turf species, but showed decreasing weed cover with increasing nitrogen rates (DeBels et al., 2012). The low rate of fertilization in our study may have resulted in a slower growth rate of kentucky bluegrass, and gave Kura clover more opportunity to establish. The fertilizer requirements for grass establishment in our plots were likely on the low side of recommended rates as a result of the loamy soil, conservative cutting regime, and the fact that clippings were left on the field.

There was lower establishment of Kura clover in trial 2 compared with trial 1 despite efforts to keep establishment conditions (i.e., nutrient availability and soil moisture content) consistent. Kura clover is known to be highly variable in its establishment (Seguin et al., 1999) and was noted as being potentially sensitive to establishment conditions. Climatic conditions and time of establishment between trial years were somewhat different, with average temperatures during the first week of establishment being somewhat higher during trial 1 than trial 1 (2 °C for high temperatures and 4 °C for low temperatures). This higher average temperature during trial 1 may have been responsible in part for the greater rates of establishment compared with trial 2. Soil testing for both

Table 2. Analysis of variance results conducted for trial 1 established in 2013 and trial 2 established in 2014. Within each trial, we tested for the effect of grass species (GS), seeding rate (SR), and their interaction on average Kura clover trifoliate leaf and bloom count.

Factor	df	*F* value	*P* value
Trial 1			
Trifoliate leaves			
GS	3	21.73	<0.001*
Kura SR	2	2.05	0.151
GS × SR	6	0.83	0.557
Blooms			
GS	3	2.97	<0.001*
SR	2	0.19	0.133
GS × SR	6	0.14	0.302
Trial 2			
Trifoliate leaves			
GS	3	4.03	0.019*
SR	2	2.68	0.089
GS × SR	6	0.87	0.529
Blooms			
GS	3	6.95	0.002*
SR	2	0.29	0.748
GS × SR	6	0.89	0.515

*Significant result.

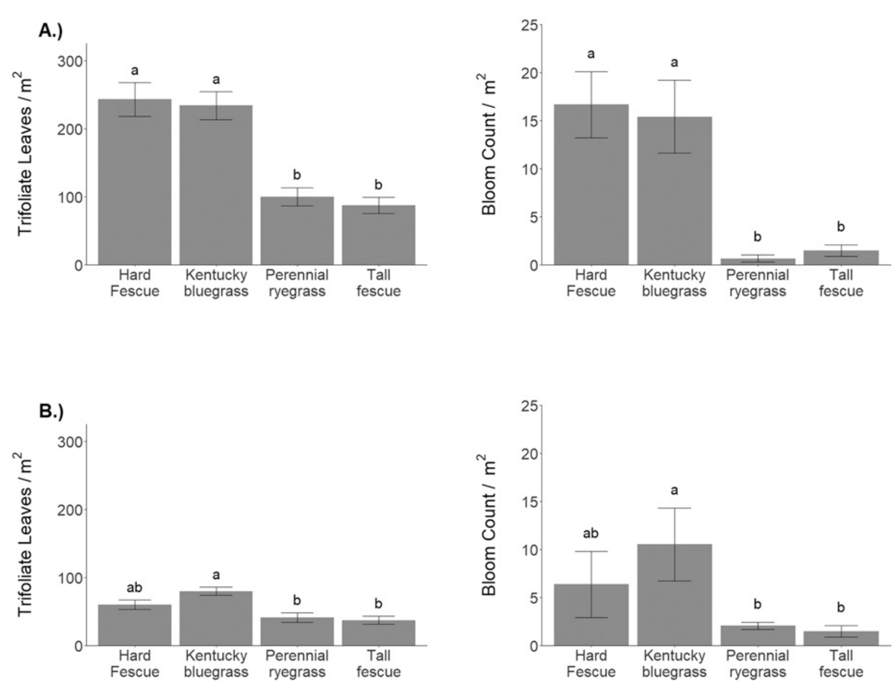

Fig. 1. (**A**) Bar plots of mean seasonal Kura clover blooms and trifoliate leaves for trial 1 in 2014 and (**B**) trial 2 in 2015 in four different grass species. Error bars represent SE and letters represent statistical differences as determined by pairwise comparison using Tukey's mean separation protocol with α = 0.05.

trials revealed that the nutrient conditions and organic matter for the two trials were strikingly similar, and thus fertility as a primary driver for differences between trials seems unlikely (see Supplemental Table 1 for soil analysis).

One potential explanation for lower Kura establishment could be the result of greater levels of competition. The field space where trial 2 was established was prepared for planting in 2013 through tilling and leveling, but was left fallow for 1 year without further cultivation. Although direct measurements of weed pressure were not taken as a part of this study, it is possible this fallow period without further cultivation might have led to a larger weed seed bank, and thus greater weed pressure on plot establishment in trial 2 (Froud-Williams et al., 1983; Roberts and Dawkins, 1967). This weed pressure may have also interfered with the establishment of the turfgrass species as well, but we were unable to assess this because we did not collect data on turf establishment past visual confirmation.

Although weed pressure may have been different between trials, the relatively small footprint of the research area and the randomization process of the plots was likely consistent enough across a given trial not to interfere with seeding rate and grass species treatment analysis within a given trial. Thus, our consideration of each trial separately addresses issues of potential differences in weed pressure between trials adequately. It is possible that weed pressure may have affected Kura clover establishment indirectly through competition with the different turfgrass companion species, but this is impossible to tell from our data. Although Kura establishment was less on the whole in trial 2, the pattern of establishment was somewhat consistent between trials, with the most glaring difference being that Kura clover establishment in hard fescue was not statistically different from the other grass species in trial 2. Although Kura clover establishment does trend higher than in perennial ryegrass and tall fescue, it is likely that a combination of environmental factors interacting with hard fescue in trial 2 modified its competitive interactions with Kura clover. Fine fescues are known to suppress weed growth, (Bertin et al., 2003, 2009), and there is some evidence this suppression relies on environmental conditions (Bertin et al., 2009).

Other studies have found effects of turfgrass species on forb establishment. A recent study involving white clover co-seeded with companion grasses into dormant bermudagrass found clover produced more trifoliate leaves in tall fescue compared with the faster growing varieties such as annual ryegrass (McCurdy et al., 2013). A similar study used three species of turfgrass co-seeded with birdsfoot trefoil (*Lotus corniculatus* L.), and found that kentucky bluegrass and red fescue typically had greater yields of birdsfoot trefoil than perennial ryegrass (Laskey and Wakefield, 1978). These studies generally support the hypothesis that slow-growing grasses are more amenable to the growth of companion forbs, although there is also evidence that tall fescue is partially allelopathic to species in the clover genus (*Trifolium*) (Springer, 1996). Our results generally support these findings, but have expanded them to include flowering response, suggesting that grass species could be an important consideration for managing turf for high floral densities. Although our study was constrained to Upper Midwest of the United States, the number of studies with similar results span many climatic zones, suggesting this relationship could be applicable in a range of systems.

Mowing and public use have been found to affect lawn community diversity negatively (Bertoncini et al., 2012; Shwartz et al., 2013), but the species of turfgrass used in lawns also has an important impact on whether flowers can establish and continue to bloom in lawns. Our study combined with other previous research suggests that slow-growing turfgrasses such as kentucky bluegrass and hard fescue could be good candidates for future lawn forb trials aimed at identifying new species for flowering lawn mixes, especially those that are slow growing and have challenging germination requirements. One important factor we did not explore is how populations of flowers might change as turf swards mature, whether their populations are truly sustainable in the long term, and whether grass species impact this. Long-term stability of flower populations in turf lawns is key to the goal of maintaining diversity and an important avenue of future research. Ultimately, finding commercially available flowers that can tolerate mowing, create acceptable aesthetics, provide bee forage, persist long term, and meet the needs of landowners is a challenge. This work attempts to address one of these challenges; our future studies will build off these results to provide useful forb–lawn mixtures.

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Supplemental Table 1. Soil test.

Laboratory ref. no:	Soil job #125 2015–16					Research Analytical Laboratory
Report to:	Ian Lane					University of Minnesota
Date received:	3/10/2016					1902 Dudley Ave.
Date reported:	3/17/2016					St Paul, MN 55108
Study name:	Bee Lawn					
Sample type:	Soil					
Laboratory no.	Sample ID	Bray P (ppm)	NH_4OAc-K (ppm)	LOI OM (%)	Water pH	
1	Trial One	101 / 101	274 / 278	4.6 / 4.6	6.5 / 6.5	
2	Trial Two	105	286	4.5	6.1	

FLOWERING BEE LAWNS

A TOOLKIT FOR LAND MANAGERS

Compiled by
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Nelson Lab: Depts of Forest Resources & Fisheries, Wildlife & Conservation Biology

Bee Lab

Minneapolis Park & Recreation Board

Turfgrass Science

Environment and Natural Resources Trust Fund

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INTRODUCTION

Flowering Bee Lawns

Scientists at the University of Minnesota research *flowering bee lawns* as a concrete way that public land managers and homeowners can support bees. Many bee pollinator populations are in decline due to several factors, including a lack of bee-friendly flowers, exposure to pesticides, as well as diseases and parasites. Turfgrass lawns are ubiquitous in urban and suburban areas, covering more than 2% of the land area of the continental U.S., but don't provide nectar or pollen for bees. Flowering bee lawns incorporate low-growing, perennial flowers into turfgrass lawns. The selected flowers are rich sources of nectar and pollen for bees and can withstand mowing and moderate foot traffic. This means flowering lawns can support bees while preserving the open sightlines and many of the recreational uses provided by traditional lawns (Table 1).

Flowering lawns increase the diversity and abundance of flowers, helping support both honey bees and native bees. So far, we have found 56 species of bees feeding on Dutch white clover alone. That represents roughly 15% of all known bee species in the entire state of Minnesota.

Flowering bee lawns are designed to be easy to install, either through overseeding or as part of a new lawn renovation. Once installed, flowering bee lawns should require minimal maintenance with just a few alterations to typical lawn management practices.

Research Project Background

This toolkit is based on research by the University of Minnesota Bee Lab, Turfgrass Science Lab, and Nelson Lab in partnership with Minneapolis Park and Recreation Board with funding from the Minnesota Environmental and Natural Resources Trust Fund (ENRTF).

The first research phase determined which low-growing flowering plants could sustain growth within turf and continue to flower after mowing.

In the second phase, we…

a. tested flowering lawns in public parks to see if they increase the diversity and abundance of honey bee and native bee pollinators.
b. surveyed Minneapolis park visitors to learn about their perceptions of bee pollinators and flowering lawns, and
c. conducted focus group interviews with public land managers representing 25 local, county and regional park departments from the 7-county Twin Cities Region.

Comparing Flowering Bee Lawns with Other Types of Vegetation

Flowering bee lawns combine features of traditional turfgrass lawns and other types of vegetation supporting bees and preserving the open sightlines and many recreational uses associated with lawns.

	Traditional turf	Bee Lawn	Urban meadow	Native prairie	Pollinator garden
Description	Area dominated by & managed for turfgrasses. Turf that has not been treated with herbicides may have unintentional forbs.[1]	A mix of low-input turfgrasses & low-growing forbs selected to provide bee forage. Mowed regularly to maintain recreational uses similar to lawns.[4]	"Naturalistic, unmown grassland with or without flowering forbs."[5]	Area dominated by grasses & grass-like species, often with a diverse assemblage of forbs & other plant species.[9]	Garden bed planted with species selected to provide high-quality pollinator forage.
Key criteria for selecting species	Appearance (e.g. color, texture); Maintenance requirements	Provision of pollinator forage (& other ecological benefits); Ability to grow in lawn conditions	Biodiversity (& other ecological benefits); Appearance/color diversity	Native species (& other ecological benefits)	Provision of pollinator forage (& other ecological benefits)
Vegetation height	Short (2-4.5 inches)[3]	Short (2-4.5 inches)[3]	Short (2 inches) to Tall (40 inches) [5]	Short (6 inches) to Tall (120 inches)[9,11]	Varies
Suitability for foot traffic	Excellent	Good	Poor to None	None	None
Mowing frequency	1-6/month[2,3]	1-3/month[4]	1/month to 1/season[5]	0-2/season[10]	N/A
Other maintenance considerations	Staff are usually already familiar with & skilled at maintaining.	Can mow less frequently than traditional turf. No new equipment is necessary. Herbicide use should be avoided.	Mowing is substantially reduced. Removal of plant residues may require additional equipment/effort.	May be maintained by prescribed burns. Requires specialized training and equipment.	Requires intensive management, such as hand weeding & mulching.

Illustration by Joseph Nowak III. References: [1]Ignatieva, Eriksson, Eriksson, Berg, & Hedblom, 2017; [2]Yue et al., 2017; [3]Cornell University, 2018; [4]Lane, 2016; [5]Southon et al., 2017 (p.106); [6]Hoyle et al., 2018; [7]Smith & Fellowes, 2015; [8]Smith & Fellowes, 2014; [9]Blair, Nippert, & Briggs, 2014; [10]Minnesota Dept of Natural Resources, 2004; [11]Oregon State University, 2018.

Recommended Species

	Dutch white clover *Trifolium repens*	Self-heal *Prunella vulgaris*	Creeping thyme *Thymus serpyllum*	Ground plum *Astragalus crassicarpus*
				
Description	Legume with trifoliate, ovate leaves. Flower heads are white tinged with pink or cream.	Stems spread along the ground. Leaves are lance or ovate. Whorls of purple florets.	Woody, spreading stems, with small leaves and pink to purple flowers.	Spreading legume with pinnate leaves and purple to white pea-like blooms.
Forage for bees	Pollen and nectar	Primarily nectar, some pollen	Primarily nectar, some pollen	Nectar, possibly some pollen
Bloom Time	May to October	June to August	July to August	April to May
Bloom Height	2.5″	2.5″	2″	3″
Sun	Full sun to shade	Part shade to full sun	Full sun	Full sun
Soil types	Sandy to loam to clay	Silt/clay/loam	Prefers sandy, will establish in loam	Sandy
Native Range	Europe	North America	Northern Europe	Great Plains
Additional Notes	56 bee species have been observed foraging on this species in Minneapolis parks. As a member of the legume family, it can fix nitrogen and improve overall lawn health.	In Minneapolis parks, 96% of the bees observed on self-heal were native. The longer corolla is good for larger bees with long tongues, like bumble bees, and very small bees that can crawl into the flower.	Has small blooms good for smaller, short-tongued bees. This species is closely related to the thyme used in cooking and has a similar scent.	Blossoms can provide early-season forage, especially for large-bodied, long-tongued bees. It is in the legume family and can fix nitrogen. Seeds may be hard to find or expensive.

Establishment & Maintenance

Adapted from public outreach materials by James Wolfin

Site & Species Selection

It is crucial to pick a site where flowering lawns are a good fit in terms of biophysical factors as well as park use.

Our survey in Minneapolis found that 95-97% of park visitors supported flowering bee lawns in parks. Survey respondents liked the way flowering lawns look and they wanted to support bee pollinators. A small percentage of visitors expressed concern about the risk of bee stings. With these perceived benefits and concerns in mind, we suggest a few approaches for selecting a site for a flowering bee lawn, each with different tradeoffs:

(1) A high-visibility, high use site will allow for more opportunities for education and engagement. Signage can highlight the aesthetic benefits as well as the benefits to bees.

(2) A low-visibility, low-use area will still provide forage for bees, but may reduce potential concerns from park visitors.

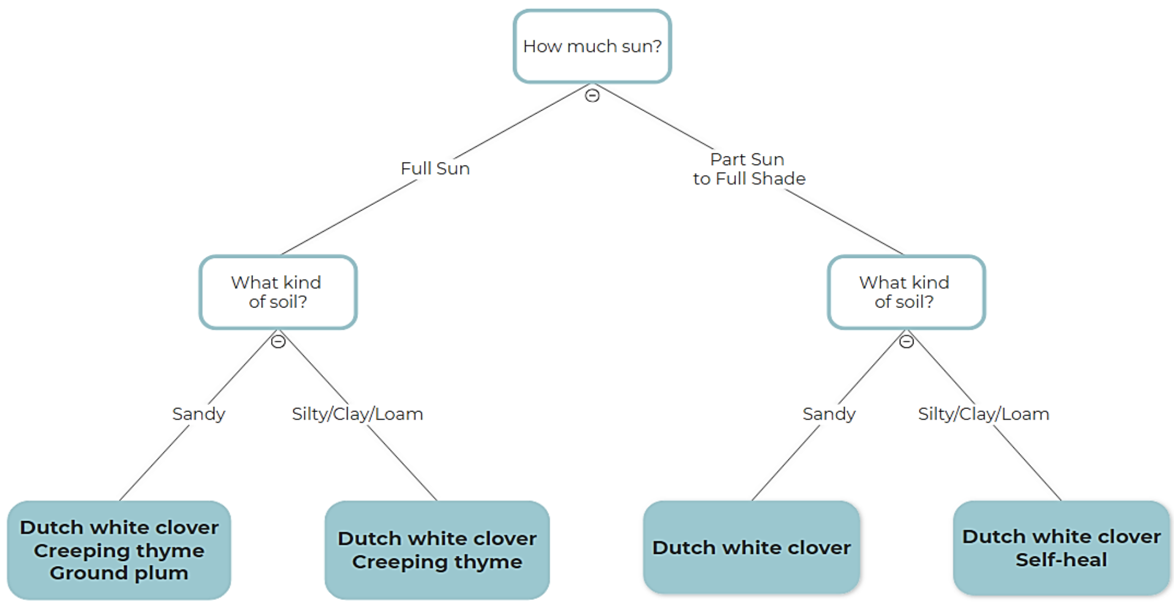
(3) A high visibility, low-use location away from ball fields or playgrounds but near walking paths or parkways may offer a happy medium. Visitors can easily choose how close to get.

(4) You may already have a 'partial' bee lawn if you have Dutch white clover in your turf. In this case, the public is already accustomed to it, and you can consider enhancing these clover areas by adding a greater diversity of species.

The particular flowering species that best suited to your site will depend on the sunlight and soil conditions (see diagram). Choose sites that receive at least some sunlight, because honey bees prefer warm temperatures for foraging.

For turfgrasses, Kentucky bluegrass *(Poa pratensis)* and fine fescues *(Festuca spp.)* work well in bee lawns. Fine fescues are lower input and work better in shady sites than Kentucky bluegrass. We don't recommend perennial ryegrass (*Lolium perenne)* or tall fescue (*Festuca arundinacea).*

Depending on the season, water access may be helpful during establishment. No irrigation is required if you choose a dormant seeding in the late fall. For a spring seeding, irrigation is recommend for the first 30 days.



Buying seed

The UMN Bee Lab developed the Bee Lawn Mix for lawn renovation projects. The mix contains strong creeping red fescue, Chewings fescue, hard fescue, sheep fescue, Dutch white clover, creeping thyme, and self-heal.

As of spring 2019, the Bee Lawn Mix is available at:

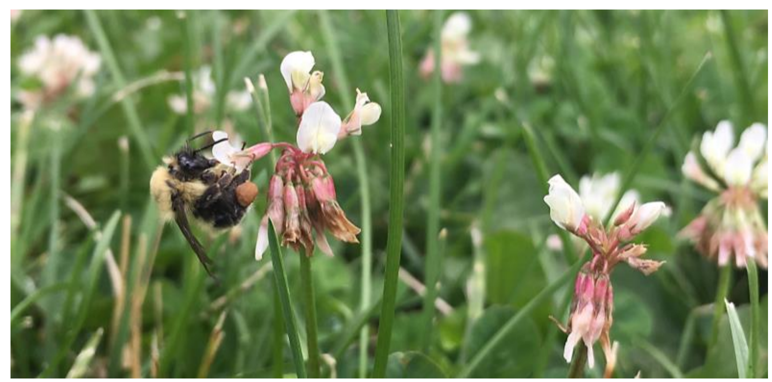
- **Otten Brothers Garden Center**
  952-473-54-25
  2350 Wayzata Blvd, Long Lake, MN
- **Beisswenger's Hardware**
  651-633-1271
  1823 Old Hwy 8 NW, New Brighton, MN
- **JK Landscape & Construction**
  320-558-4445
  19512 Hubble Road, Clearwater, MN
- **Organic Lawns by Lunseth**
  612-226-1898
  Installation only
- **Jerry's Hardware**
  952-929-4601
  5115 Vernon Ave S, Edina, MN

  952-884-2209
  10530 France Ave S, Bloomington, MN
- **Eggplant Urban Farm Supply**
  651-645-0818
  1771 Selby Ave, St. Paul, MN
- **Leitners Garden Center**
  651-291-2655
  945 Randolph Ave, St. Paul, MN

You can also make your own seed mix for overseeding or lawn renovations. Use the table below to calculate the amount of seed needed based on the size of the area you want to plant.

SEEDING RATE

Common name *(Latin name)*	Seeding rate per 1000 sq ft
Dutch white clover *(Trifolium repens)*	1.1 oz
Creeping thyme *(Thymus serpyllum)*	0.16 oz
Self-heal *(Prunella vulgaris)*	1.2 oz
Ground plum *(Astragalus crassicarpus)*	3.0 oz
Fine fescue* *(Festuca spp.)* *For lawn renovation only, not necessary if overseeding	4 lbs



When to Install a Bee Lawn

We strongly recommend a dormant seeding in the late fall, whether overseeding flowers into existing turf or establishing flowers alongside new turfgrasses. The goal is to target a time when soil temperatures have dropped below 40°F, typically around the third week of November in Minnesota. At this soil temperature, it is too cold for seeds to germinate, but the ground is not yet frozen. This gives plants the best chance to germinate the following spring and reduces competition from surrounding plants. Overseeding in the early spring is also an option, though bee lawn flowers will face more competition from established lawn weeds.

Site Prep

The kind of site preparation required depends on whether you will be overseeding flowering species into an existing lawn area, or whether you'll be eliminating the existing vegetation and planting turfgrasses and flowering species at the same time:

Overseeding	Lawn renovation
Before seeding bee lawn flowers, we recommend: (1) Scalping (or mowing to ≤1 inch) to allow better soil-to-seed contact and reduce competition for sunlight (2) Core aeration to increase the flow of air, water, and nutrients, and to alleviate the stresses associated with soil compaction	Eliminating pre-existing turfgrasses or weed species can reduce competition for bee lawn seeds, but it is more expensive. Suggested methods include using a sod cutter, herbicides, or solarization. Note: Many herbicides contain ingredients harmful to pollinators. Avoid these if possible.




Seeding

Apply a starter fertilizer along with, or immediately following seeding.

For dormant seeding in the late fall (highly recommended), no irrigation is required. If you overseed in the spring, irrigation for the first 30 days will help with establishment.

For lawn renovations, lightly rake soil over seeds after spreading. During the first week, irrigate the area several times each day to keep the soil moist. This is generally accomplished with three irrigation cycles spaced evenly throughout the day (e.g. 8am, noon, and 4pm). Application rates should be approximately 0.10" of water during each irrigation cycle. Fine fescues will germinate anywhere from 4-8 days. Following germination, reduce irrigation by adjusting the frequency to 2x per day for 5-7 days, followed by 1x per day until irrigation can be withheld. This assumes no rainfall. Be sure the area does not stay constantly wet (maintain moisture but not saturation) and withhold irrigation when rainfall is sufficient. Use a germination blanket to keep the seeds in place and to retain moisture. As with any new lawn establishment, temporary fencing may be necessary for 1-2 months until bee lawn is established. *Blooms may not be observed for certain flowers until 1-2 seasons after seeding.*

Maintenance

Once established, maintenance practices for flowering bee lawns are largely similar to those for any other low-maintenance turf lawn area.

MOWING Bee lawns can be mowed regularly, ~1-3 times/month. Allow vegetation to grow to at least 2.5 inches (ideally a bit more) to encourage blooms.	WEEDS Refrain from using broad-spectrum herbicides, which would kill bee lawn flowers. Hand weeding or a spot treatment is recommended.
FERTILIZER Once established, no additional fertilizer is needed. Dutch white clover will fix nitrogen.	IRRIGATION No additional inputs of water should be required.

OUTREACH & EDUCATION

Balancing Benefits and Concerns

When we surveyed park visitors in Minneapolis, 95-97% supported creating flowering lawns in public parks. Aesthetics and supporting bees were the two most commonly mentioned potential benefits of flowering lawns (and that was even before we explained that flowering lawns were designed to provide food for bees). Selecting a location for a flowering lawn that (a) is visible and (b) where park visitors are able to observe bees if they choose could enhance perceived benefits.

On the other hand, the 2-5% of survey respondents did not support flowering lawns and expressed concerns about bee stings, especially in play areas used intensively by small children who may not know how to calmly avoid bees. Selecting locations that (a) have low to moderate foot traffic and/or (b) can be easily avoided if park visitors prefer, could help alleviate the concerns of some park visitors. Finding the right place for your community and your parks is important for success.

Crafting a Message

It's important to tailor the message to your audience. Some park visitors will be most excited about bees while others will be enthusiastic about adding more color to the landscape. Our research suggests that solely discussing the benefits to bees is likely to engender both stronger support as well as stronger opposition. When we shared the flowering lawns were designed for bees, strong support for flowering lawns increased by 12%, but overall support decreased by 1.8%. Emphasizing things like the aesthetic benefits, biodiversity, nitrogen fixation, or reducing herbicides might resonate more strongly with some.

It's much easier to win support by emphasizing benefits that community members already care about, so it's important to learn more about what your community members value most and then tailor your message.

START SMALL OR GO BIG?

Depending on your community, it might make sense to first try out flowering bee lawns on a small scale, in an out-of-the-way spot where you can monitor the establishment and see how it could fit in to your park system and maintenance practices. That trial run could reveal where you'd like to make adjustments and help you build a case for wider scale adoption.

On the other hand, there may already be an organized group of pollinator supporters or a pollinator-friendly ordinance in your community. Establishing a bee lawn in a highly visible area and promoting it widely could help your community advertise the innovative practices that you use and the ecological benefits your park system provides.

Getting the Word Out

People tend to view alternative vegetation in a positive light when there are clear signals that it is a result of intentional design choices (Nassauer, 2011). In our research in the Twin Cities region, some park visitors and land managers expressed concern that community members who aren't familiar with flowering lawns could assume the low-growing flowers are weeds and they may be interpreted as a sign of neglect. Elsewhere, researchers found that public garden visitors didn't notice when flowers were added to lawn areas unless there was signage or a public event (Shwartz, Turbé, Simon, & Julliard, 2014). Some community members may not even notice a change or be aware of the ecological benefits.

Signage on-site at flowering lawns can help communicate to park visitors that the flowers were intentionally added to the turf and that they are serving an important ecological function. In addition to signage, you can also publicize the benefits of flowering lawns through newsletters, flyers, your website, social media, educational programs, or public events.

Frequently Asked Questions

While attention to pollinator and bee conservation has surged recently, flowering bee lawns are still a relatively new concept. Community members may have questions about flowering bee lawns, so here are some answers to have at the ready:

WHAT IS A FLOWERING LAWN?
Flowering bee lawns are turfgrass areas with low-growing, perennial flowers mixed in. You can walk on them and mow them like a regular lawn, and the flowers provide food for bee pollinators. This means that flowering lawns can support bees and while preserving the open sightlines and most recreational uses of traditional lawns.

ARE THESE WEEDS?
No. A weed is a plant growing in a place you don't want it. These flowers were intentionally chosen because they are rich sources of nectar and pollen for honey bees and native bees (and because they withstand mowing and foot traffic). We want these flowers right where they are because they provide important environmental benefits.

CAN I WALK ON A FLOWERING LAWN? WILL I DAMAGE IT?
You are more than welcome to walk on flowering lawns! Regular recreational uses like walking through, sitting on, playing catch or pickup sports on the flowering bee lawn won't damage it. The flower species were specifically chosen to be able to withstand moderate foot traffic.

DOES MOWING DAMAGE FLOWERING LAWNS?
Mowing does not damage flowering lawns. The flowers in the bee lawn mix were chosen because of their ability to bloom at low heights and to keep growing after being mowed. Allowing the vegetation to grow to 2.5 inches or more will encourage the most blooms.

HOW DO FLOWERING LAWNS HELP BEES?

Many bee species populations are declining because of several factors, including a lack of bee-friendly flowers, exposure to pesticides, diseases, and parasites. Turfgrass lawns cover a huge amount of land, but they don't provide much food for bees. Flowering lawns incorporate low-growing flowers into lawns to provide rich sources of nectar and pollen. U of M researchers found 56+ species feeding just on Dutch white clover in Minneapolis parks. That's nearly 15% of the ~400 bee species in the state!

I DON'T LIKE BEES. WHY ARE YOU ATTRACTING THEM TO PARK AREAS?

Our parks are committed to providing high quality recreational opportunities and ecological benefits such as plant pollination at the same time. We believe that increasing bee-friendly flowers in park areas that don't conflict with recreational uses can serve both of these crucial goals at the same time.

WHY ARE BEES SO IMPORTANT ANYWAY?

In a word: pollination. As bees collect nectar and pollen for food, they also end up transferring pollen from flower to flower. More than one-third of the world's crops species rely on bee pollination and 80% of wild plants depend on bees or other animals for pollination. Maintaining bee diversity is crucial for ecosystem health.

WHAT IS THE DIFFERENCE BETWEEN WASPS & HONEY BEES?

Bees are fuzzy and wasps appear shiny and hairless. A wasp can sting multiple times but if a honey bee stings, it dies. Wasps tend to be more bothersome at picnics.

WHAT ABOUT CREEPING CHARLIE?

Creeping Charlie can be a source of nectar for some species of bees, but its pollen isn't readily available to visiting insects. It can also be fairly invasive. We don't recommend it in flowering lawns.

ARE THERE OTHER BENEFITS OF FLOWERING LAWNS?

Aside from providing nectar and pollen for bees, flowering lawns with low-input turf species can also decrease the maintenance and input requirements of lawn areas. For example, we may be able to mow bee lawns less frequently, saving money and staff hours and reducing CO_2 emissions from mowers. Dutch white clover fixes nitrogen, helping to build an important nutrient in the soil. Lastly, flowering lawns don't require irrigation after the establishment phase, which conserves water.

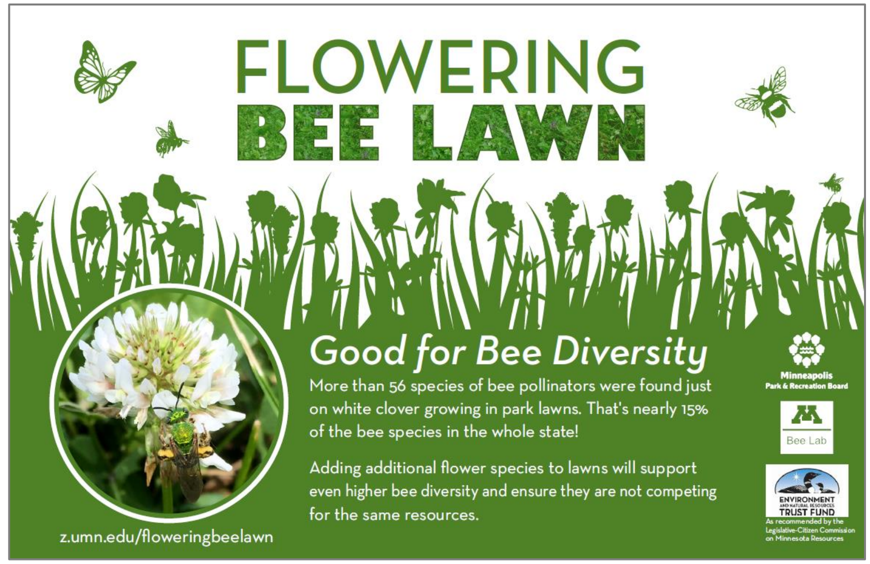
CAN I PLANT A FLOWERING BEE LAWN IN MY YARD?

Absolutely! The more habitat we can create for bee pollinators, the better. Plus, if you grow vegetables or fruit in your yard, attracting pollinators may help increase your harvests.

To learn more about how to start a flowering lawn in your yard, visit z.umn.edu/floweringbeelawn

Sample Outreach Signs / Posters

Electronic versions will be available on the Bee Lab website at z.umn.edu/floweringbeelawn starting in August 2019.



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Research Paper

Exploring park visitor perceptions of 'flowering bee lawns' in neighborhood parks in Minneapolis, MN, US

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ABSTRACT

Flowering bee lawns integrate low-growing flowers into mowed turfgrass to increase the availability of bee forage. They also maintain many of the aesthetic and recreational functions of the lawns in urban green spaces. Common cultural preferences for uniform, green, grass-monoculture lawns may pose a barrier to widespread adoption of flowering lawns. However, a growing body of literature suggests that there may be a higher degree of acceptance of lawn alternatives, such as grass-free lawns or urban meadows, than previously thought. We examined park visitors' perceptions of flowering lawns at four parks in Minneapolis, U.S. through an on-site questionnaire survey using photos. When first asked, 97.2% of respondents supported implementing flowering lawns in public parks. Informing participants that flowering lawns are designed to provide bee forage had a polarizing effect where strong support increased yet overall support declined slightly. Positive perceptions of bees and of flowering lawn appearance were the only two significant factors associated with support for flowering lawns in both pre- and post-informational intervention logistic regression models. Similarly, aesthetics and benefits to bees were the most frequently stated perceived benefits. When asked about concerns, the most frequent responses were 'no concerns' and 'reduced recreational use of lawns'. For public land managers who wish to add flowering lawns to their suite of green infrastructure options to increase forage availability for bees, our findings suggest there is widespread public support. Public engagement should be carefully crafted to address concerns about flowering lawns and reinforce existing positive perceptions.

1. Introduction

Urban parks and other green spaces are complex socio-ecological systems (Hunter & Luck, 2015; Jorgensen & Gobster, 2010) that can play an important role in supporting human health and well-being (Chiesura, 2004; van den Bosch & Sang, 2017) as well as increasing biodiversity (Shwartz, Muratet, Simon, & Julliard, 2013), sequestering carbon, reducing air pollution, and providing other important ecological benefits (Derkzen, Teeffelen, & Verburg, 2015; Mexia et al., 2018). Flowering lawns are a mix of turfgrasses and low-growing flowers designed with dual goals: to increase the availability of high-quality nectar and pollen for bees, and to maintain the recreational uses and aesthetic preferences of traditional mown lawns. Recognizing that park visitors' values, preferences, and uses of parklands are central to the design and management of urban parks (Hunter & Luck, 2015), this paper examines visitor perceptions of flowering bee lawns and explores how these may affect adoption in urban landscapes. We begin with a brief discussion of recent insights about the cultural importance of lawns and their ecological impacts.

1.1. Lawns as socio-ecological systems

Turfgrass lawns are a dominant feature of urban green spaces, particularly in temperate climates (Hedblom, Lindberg, Vogel, Wissman, & Ahrne, 2017; Irvine et al., 2009; Stewart et al., 2009; Wheeler et al., 2017). In the U.S. alone, lawns cover an estimated 1.9% of the total land area, compared to the estimated 3.5–4.9% covered by urban development (Milesi, Running, Dietz, & Tuttle, 2005). Rooted in centuries-old European landscape design traditions, grass lawns have a long history as material manifestations of orderliness, mastery over nature, and social status (Byrne, 2005). The cultural importance of lawns persists today and well-kept lawns have been associated with good moral character, neighborliness, and higher property values (Blaine, Clayton, Robbins, & Grewal, 2012; Ignatieva et al., 2015; Nassauer, Wang, & Dayrell, 2009; Robbins & Sharp, 2003). The appearance of lawns is often listed as their most important feature (Blaine

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et al., 2012), with preferences for dense coverage, light green color, a limited number of grass species, and the absence of weeds (Yue et al., 2017).

The potential for lawns to affect ecosystems, either positively or negatively, is largely determined by the management practices used. These can vary substantially between regions, neighborhoods, and even within individual parcels (Harris et al., 2012; Martini, Nelson, Hobbie, & Baker, 2015). Compared to hard surfaces or bare ground, lawns can provide multiple ecological benefits such as carbon sequestration, erosion control, mitigation of the urban heat island effect, and reduction in air pollution (Beard & Green, 1994; Blaine et al., 2012; Milesi et al., 2005). While low-input turfgrass species have the potential to reduce fertilizer and mowing requirements (Hugie & Watkins, 2016), the most common turfgrasses require intensive management and substantial use of fertilizer, pesticides, and irrigation to maintain a uniformly thick, green monoculture (Barnes et al., 2018; Blaine et al., 2012). This may lead to ecosystem disservices such as carbon emissions from frequent mowing, water quality degradation from over-fertilization (Fissore et al., 2012), increased water consumption, and potential non-target effects of herbicides and insecticides (Robbins & Sharp, 2003). Furthermore, lawns support lower plant and vertebrate diversity compared to other types of green infrastructure, such as urban meadows (Shwartz, Turbé, Simon, & Julliard, 2014) or 'reference natural areas' (Wheeler et al., 2017).

1.2. Bee diversity

Steep losses of managed honeybee colonies have been reported in Europe and the U.S. (Goulson, Nicholls, Botías, & Rotheray, 2015), and declines in wild bee diversity have been observed in Europe (Nieto et al., 2014), the U.S. (Burkle, Marlin, & Knight, 2013; Cameron et al., 2011), China, and Japan (Goulson et al., 2015). These declines are likely driven by multiple, interacting threats including nutritional deficiencies resulting from habitat loss, diseases and parasites, and pesticide exposure (Goulson et al., 2015; Spivak, Mader, Vaughan, & Euliss, 2011). In the U.S. and the U.K., agricultural conversion has dramatically reduced floral resources (Goulson et al., 2015), so increasing bee forage availability is a key strategy for bee conservation (Lane, 2016; Nieto et al., 2014). Samuelson, Gill, Brown, & Leadbeater (2018) found that even very dense urban areas act as a refugia for bumblebees (*Bombus terrestris*), likely because cities tend to have more abundant floral resources relative to agricultural zones. It is common for lawns to contain spontaneous forbs (Muratet et al., 2008; Thompson, Hodgson, Smith, Warren, & Gaston, 2004), some of which, such as dandelion (*Taraxacum officionale*) and white clover (*Trifolium repens*), provide forage for pollinators (Larson, Kesheimer, & Potter, 2014; Lerman & Milam, 2016). However, lawn cover is dominated by turfgrasses (Thompson et al., 2004) which do not provide forage (Tonietto, Fant, Ascher, Ellis, & Larkin, 2011). Ecological modeling in Chicago suggests that replacing turf lawns with "a more florally-rich land cover" would support greater bee abundance and richness in urban areas (Davis et al., 2017, p. 157).

1.3. What is a flowering bee lawn?

Flowering bee lawns are composed of a mix of low-input turfgrasses and low-growing flowers selected to provide high-quality bee forage while still maintaining recreational uses. As a concept, flowering lawns are closely related to other types of green infrastructure but are distinct in important ways (Table 1). Relative to traditional lawns, flowering lawns are mown to similar heights, preserving recreational uses that involve walking or running across them and requiring only minimal changes in lawn maintenance regimes. Lawns that contain spontaneously-occurring forbs can support a surprisingly diverse assemblage of bees and other pollinators (Larson et al., 2014; Lerman & Milam, 2016). However, our parallel research on bee diversity and flowering

Table 1
Comparison of key characteristics of lawns, flowering lawns, and common types of lawn alternatives. Note: (a) Table entries are brief summaries rather than comprehensive definitions. There can be variation in each category. (b) Flowering lawns, urban meadows, grass-free lawns, and native grasslands tend to be substantially better sources of bee forage relative to traditional lawns. (c) "Suitability as a surface for foot traffic" was inferred by authors based on McCormack, Rock, Toohey, & Hignell (2010) and Sherratt (2014) and the reported vegetation height and evenness of each type.

	Brief description	Key criteria for species inclusion	Mowing frequency	Typical vegetation height	Suitability as surface for foot traffic
Traditional lawn (multi-use)	Area planted to and managed for turfgrasses, though "it may have spontaneously occurring herbaceous species."[1] (p.213)	• Appearance (e.g. color, texture)[2] • Maintenance requirements & tolerance of foot traffic[2,3]	1–2/week[2,3] to 1–2/month[2]	Short (5–11 cm)[3]	Moderate to High
Flowering lawn	A mix of turfgrasses and low-growing forbs intentionally selected to provide high-quality bee forage. Mowed regularly to maintain recreational uses similar to lawns.[4]	• Provision of pollinator forage (& other ecological benefits)[4] • Ability to compete with turfgrasses & withstand regular mowing[4]	1–3/month[4]	Short (5–11 cm)[4]	Moderate
Urban meadow	"Naturalistic, unmown grassland with or without flowering forbs."[5] (p.106)	• Biodiversity & other ecological benefits[5,6] • Appearance/Color diversity[5]	1/month to 1/season[5]	Short (5 cm) to Tall (100 cm)[5]	Low to None
Grass-free lawn	Mixed planting of "mowing tolerant clonal perennial forbs"[7] (p. 491) without grasses.	• Ability to withstand mowing[7] • Similar growth rates relative to other species included[8]	1–2/month[7]	Short (2–9 cm)[7]	Low
Native grassland (remnant or restored)	Area dominated by grasses and grass-like species, often with a diverse assemblage of forbs and other plant species.[9]	• Native biodiversity & other ecological benefits[9,10,11]	0–2/season May also be maintained by prescribed burns[10]	Short (15 cm) to Tall (300 cm)[9,11]	None

References for table:[1]Ignatieva, Eriksson, Eriksson, Berg, & Hedblom, 2017; [2]Yue et al., 2017; [3]Cornell University, 2018; [4]Lane, 2016; [5]Southon et al., 2017a,b; [6]Hoyle et al., 2018; [7]Smith & Fellowes, 2015; [8]Smith & Fellowes, 2014; [9]Blair, Nippert, & Briggs, 2014; [10]Minnesota Dept of Natural Resources, 2004; [11]Oregon State University, 2018.

lawns suggests that by intentionally selecting forb species with favorable forage characteristics, flowering lawns can support higher bee diversity than lawns with spontaneously-occurring forbs (*unpublished data, manuscript in preparation*).

1.4. Prospects for adoption of flowering lawns

Conceptually, flowering lawns combine key features and uses of traditional lawns and lawn alternatives, particularly urban meadows. Based on the existing literature, we hypothesize that this hybridity provides both potential opportunities for public acceptance as well as barriers to adoption.

1.4.1. Integrating flowers into lawns: aesthetic preferences and perceived biodiversity

Uniform greenness and the control of non-turfgrass species are important lawn design principles in Western landscape architecture traditions influential in Europe, Australia, New Zealand (Ignatieva et al., 2015; Ignatieva, Eriksson, Eriksson, Berg, & Hedblom, 2017), as well as the U.S. and Canada (Yue et al., 2017). Particularly in these cultural contexts, the presence of forbs in flowering lawns may elicit a negative response. Conversely, humans have a psychological predisposition in favor of cultivated flowers (Haviland-Jones, Rosario, Wilson, & McGuire, 2005). Preferences for diverse and brightly colored flowers have been reported for street plantings in Japan (Todorova, Asakawa, & Aikoh, 2004) and urban meadows in the U.K. (Hoyle et al., 2018). This suggests that park visitors may view the presence of brightly colored forbs positively, however, these studies examined flower species with blooms that are larger and taller than would be typically included in flowering lawns, so it is unclear if these findings are transferable to a lawn context. It is also possible that urban residents will not notice the addition of flowering species, as was the case with the addition of flower meadows in urban gardens in Paris (Shwartz et al., 2014).

More broadly, a growing body of research suggests that urban residents highly value perceived biodiversity in green space (Belaire, Westphal, Whelan, & Minor, 2015; Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007; Lindemann-Matthies & Bose, 2007; Lindemann-Matthies, Junge, & Matthies, 2010). Some studies have found a gap between perceived and actual species richness (Belaire, Westphal, Whelan, & Minor, 2015; Dallimer, Irvine, Skinner, Davies, Rouquette, Maltby, Warren, Armsworth, & Gaston, 2012) while others found that perceived and actual richness was correlated (Hoyle et al., 2018; Southon, Jorgensen, Dunnett, Hoyle, & Evans, 2017a, 2017b). Color diversity, in terms of both vegetation color and flower color, is an important factor in public perception of biodiversity (Hoyle et al., 2018; Lindemann-Matthies et al., 2010; Southon et al., 2017b), perhaps even more important than actual species richness (Hoyle et al., 2018). These findings suggest flowering lawns that incorporate forbs with multiple flower colors could be perceived as more biodiverse and more attractive.

1.4.2. Perceptions of bees

Perceptions of bees are also likely to impact support for flowering lawns if park visitors are aware that flowering lawns are intended to attract bees. A fear of insects is common among many children and adults, particularly towards wasps and bees that have the ability to sting (Schoenfelder & Bogner, 2017). Beyond from the discomfort caused by stings, they may represent a serious health concern for some. In the U.S., it is estimated that 1% of children and 3% of adults have systemic allergic reactions to insect stings and an additional 5% of people experience unusually large localized inflammation (Golden, 2013). We anticipate that negative perceptions of bees would reduce support for flowering lawns.

In contrast to the fear sometimes attached to stinging insects, insects that provide direct benefits to people are often viewed more positively (Schoenfelder & Bogner, 2017). This may be the case with honeybees, which provide honey as well as pollination services for many cultivated crops and wild plants (Schoenfelder & Bogner, 2017). Wilson, Forister, and Carril (2017) found that 99% of survey respondents in the U.S. said that bees were 'somewhat important' or 'critical'. While their convenience sample may have led to an overestimate of positive perceptions of bees, the results suggest that bees are highly valued, at least among some social networks. Furthermore, in the U.S., threats to honeybee colony health (e.g. Baral, 2017; Barrionuevo, 2007; Klein & Barron, 2017; Spivak, 2013) and declining native bee diversity (Winfree, Bartomeus, & Cariveau, 2011) have both received growing media attention. We expect that positive perceptions of bees will correspond to a higher level of public support for flowering lawns, though respondents may still object to locating flowering lawns in park areas used for recreation.

1.5. Research questions

Against the backdrop of this complex web of values attached to lawns, lawn alternatives, and bees, we explore visitors' perceptions of flowering lawns at four urban parks in Minneapolis, U.S., and how these might influence adoption in urban landscapes.

- To what extent do park visitors support the introduction of flowering lawns in urban parks?
- Is visitor response related to flowering lawn aesthetics, perceptions of bees and stings, frequency of park use, and/or sociodemographic characteristics?
- What are the key benefits of and concerns about flowering lawns as perceived by park visitors?

2. Research design and methods

The study described here is part of a broader research partnership between the Minneapolis Park and Recreation Board (MPRB) and an interdisciplinary group of researchers at the University of Minnesota to examine park visitor perceptions of flowering lawns as well as bee pollinator response to experimental flowering lawns sown in four urban parks. To assess public perceptions of flowering lawns prior to establishment, the present study incorporated on-site photo elicitation techniques, using three photographs including four forb species which had been sown in the pilot flowering lawns. At the time of the surveys, the sown plots were not fully established and visitors did not view flowering lawns on site.

2.1. Site selection

Minneapolis is a mid-sized city in the upper Midwest of the U.S. (population 422,000, U.S. Census Bureau, 2018). The MPRB park system has been ranked as the best in the country according to Trust for Public Lands' ParkScore®, an index based on metrics such as park access, park size, and per capita investments (Trust for Public Land, 2018). The park system includes 37 regional parks and 100 smaller neighborhood parks, with median park size of 2.3 ha. Parklands cover a total of 2052 ha, which accounts for 14.9% of the city's area (Trust for Public Land, 2018).

In 2016, the MPRB partnered with researchers at the University of Minnesota to pilot test flowering lawns in four neighborhood parks, one in each of MPRB's four geographic management divisions: Audubon Park, Kenwood Park, Matthews Park, and Willard Park (Fig. 1; details on seeding and establishment in A1). The parks were purposively selected to capture variation in terms of overall park size, the kinds of amenities at each park, and the sociodemographic characteristics of the surrounding neighborhoods (Tables A2 & A3). By doing so, we hoped to invite a wide diversity of park visitors to participate in the survey.

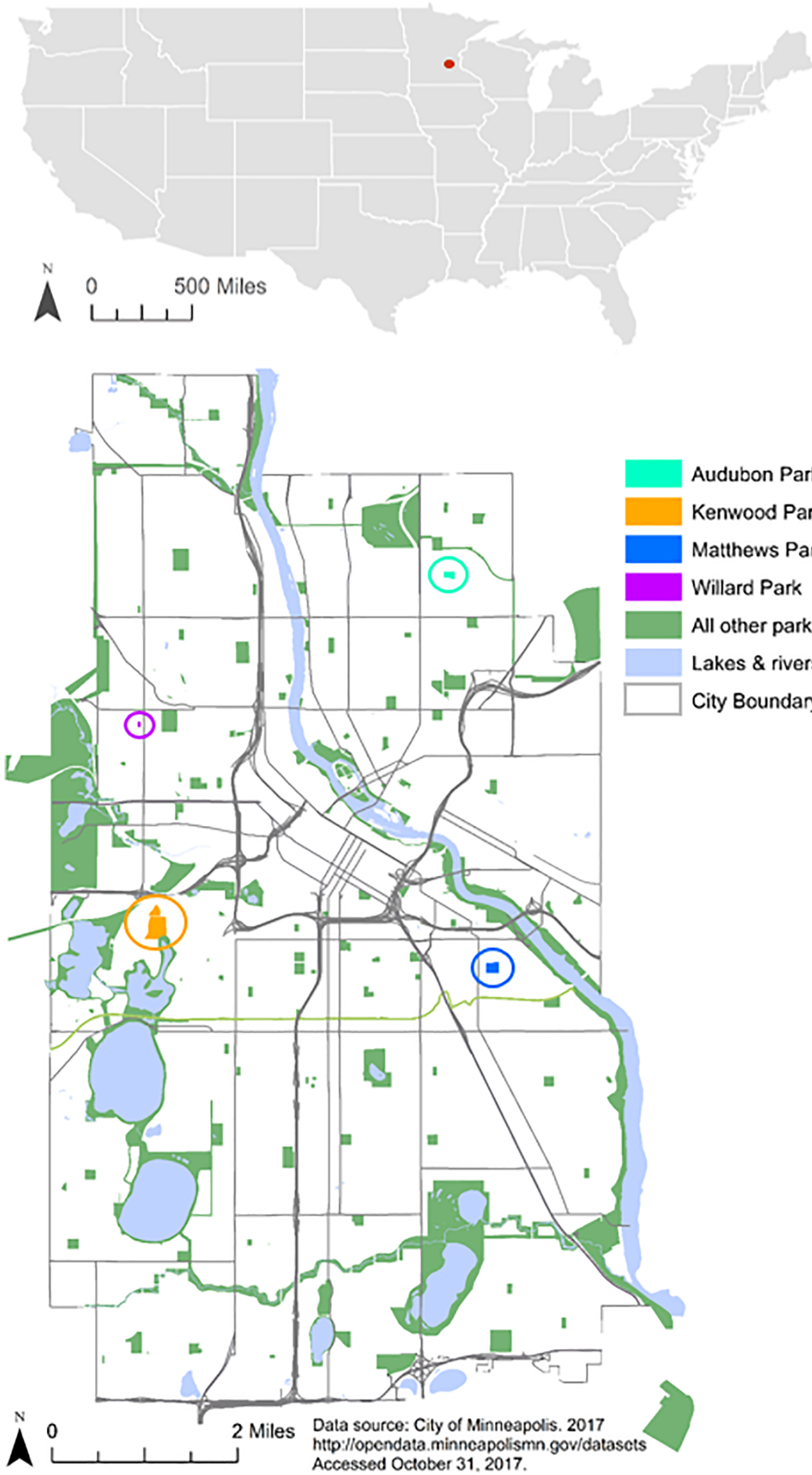

Fig. 1. Map of four parks where park visitors were surveyed in Minneapolis, MN, US.

2.2. Survey design

The questionnaire was designed collaboratively with an inter-disciplinary research team of entomologists, environmental sociologists, a turfgrass scientist, and a MPRB staff member. It was composed of 19 multiple-choice and eight open-ended questions that asked participants about their perceptions of flowering lawns, perceptions of bees and bee stings, park use characteristics, and

Table 2
Summary of on-site questionnaire, including research topics, survey items, and answer options.

Theme	Survey item	Response options
Park use	Frequency of visits to sample park	Daily, Weekly, Monthly, Annually, Never
	Frequency of visits to other parks	Daily, Weekly, Monthly, Annually, Never
	Use of grassy areas	Walk, Sit, Picnic, Informal sports, Organized sports, Other
Perceptions of flowering lawns	"I like the way flowering lawns look"	4-point scale: Strongly agree to Strongly disagree
	"I would avoid an area with a flowering lawn"	4-point scale: Strongly agree to Strongly disagree
	Benefits of flowering lawns	Open-ended
	Concerns about flowering lawns	Open-ended
	Support for flowering lawns in parks (pre- & post-information)	4-point scale: Strongly support to Strongly oppose
Perceptions of bees and bee stings	Like, tolerate, or dislike bees (pre- & post-information)	3-point scale: Like, Tolerate, or Dislike
	Benefits of bees	Open-ended
	Concerns about bees	Open-ended
	Allergy to insect stings, personal or someone in household	Yes, No, Don't know
	Level of concern about stings while at park	4-point scale: Not at all to Very concerned
	Change in concern about stings at a park with flowering lawn	5-point scale: Significantly more concerned to Significantly less concerned
Socio-demographic characteristics	Year of Birth	Open ended
	Race/Ethnicity	Amer. Indian/Alaska Native, Asian, Black or African Amer., Hispanic/Latino, White, Multiple, Other
	Highest level of education	7 categories: did not complete high school to graduate degree
	Postal code includes or borders park	Yes/No
	Live in Minneapolis	Yes/No

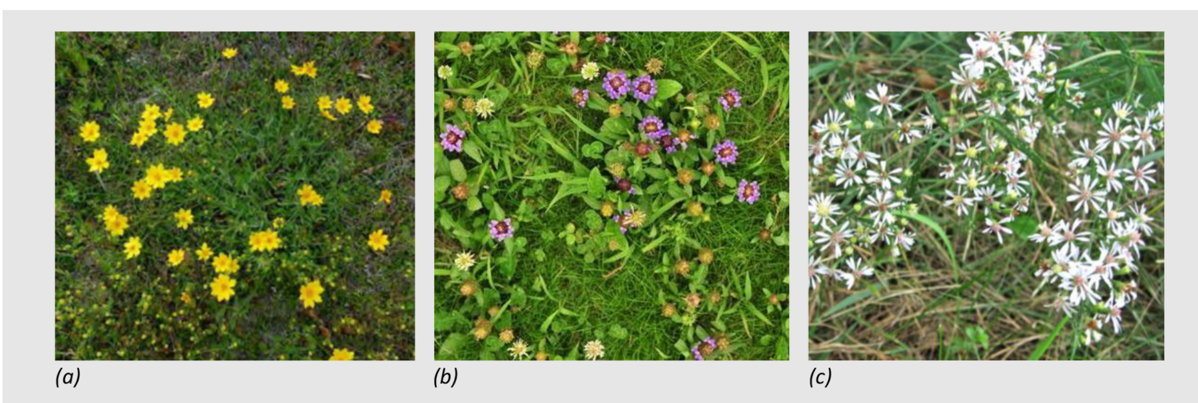

Fig. 2. Photos included on the survey: (a) lanceleaf coreopsis (*C. lanceolata*), (b) self-heal (*Prunella vulgaris*), white clover (*T. repens*) with mixed grasses, and (c) calico aster (*S. lateriflorum*). Photo credits to: (a and b) - Ian Lane; (c) - Barry Van Dusen.

sociodemographic characteristics (Table 2). Photographs of four forbs (*Coreopsis lanceolata*, *Prunella vulgaris*, *Symphyotrichum lateriflorum*, and *Trifolium repens*), all candidates for use in flowering lawns in the region, were included on the questionnaire (Fig. 2). Because flowering lawns are still experimental, there was a limited selection of photos depicting the selected forb species in combination with grasses. Two photos contained a single forb species and one photo contained two forb species. Conducting the survey on-site ensured that each participant had direct experience with the park context where they were sampled. The survey questionnaire did not explicitly ask participants to compare the photographs of forbs with existing lawn vegetation. The questionnaire included two pairs of pre/post questions, where participants encountered the same question twice: once before an informational intervention and then again after. For example, respondents were initially asked about their level of support or opposition after receiving a description that did not mention bees ("Flowering lawns have a mix of grasses and low-growing flowers") and viewing photos of the forbs seeded in pilot flowering lawns. This was intended to gauge baseline perceptions of park visitors who might encounter flowering lawns in a park without prior knowledge of them. Later in the survey, participants were informed that white clover (*Trifolium repens*) present in existing lawn vegetation supported a high diversity of bees and that new flowering lawns were designed to enhance bee forage (e.g. "The seeds in the new enhanced flowering lawns were chosen to improve the quantity and quality of food for honey bee and native bee pollinators by including different kinds of flowers." See A4 for full text). Respondents were then asked to indicate their level of support in light of this new information. This pre/post design was repeated with a pair of questions about perceptions of bees before and after receiving information about differences between honey bees and wasps (e.g. "Wasps and honey bees are quite different: A yellowjacket wasp can sting repeatedly, but if a honey bee stings, it loses its stinger and dies afterwards. You can recognize honey bees by the presence of hair on their bodies, whereas wasps are hairless." See A4 for full text.)

2.3. On-site procedure

Surveys were collected from May 31-August 28, 2017 on both weekdays and weekends between 8am and 8pm. In an effort to obtain similar numbers of completed surveys from each park, surveyors spent more hours sampling at Willard Park, due to both lower overall park visitation, especially by adults, and lower response rates.

All park visitors who were 18 years or older and who self-identified as proficient in English were considered eligible to participate in the survey. Each of the parks has multiple entry points and several differentiated recreation zones, so surveyors circulated throughout each park to maximize the number and variety of potential participants. Researchers avoided interrupting park visitors who were engaged in active sports, play, or work, though visitors were often approached before or after such activities. If park visitors were in a group, only one adult park visitor was recruited to participate per group. Four park visitors asked the surveyors to administer the questionnaire verbally, but participants typically completed the questionnaires on their own.

2.4. Data analysis

2.4.1. Assessing public support for flowering lawns

Descriptive statistics were used to compare the proportion of park visitors who supported flowering lawns across parks. We used McNemar's paired-proportions test ('caret' package in RStudio, version 1.1.419) to compare support for flowering lawns before and after the informational intervention that explained flowering lawns were designed to support bees. Thirty-five case were excluded because of missing responses to the pre/post questions for a total sample size of 502.

2.4.2. Identifying predictors of support

We used logistic regression models to examine associations between park use variables (frequency and type), perceptions of flowering lawns (appearance and avoidance), perceptions of bees (pre- and post-informational intervention) and bee stings (level of concern, change in concern with presence of flowering lawns, allergy of household member to bee stings), as well as individual characteristics (age, race and ethnicity, education, postal code that includes or borders park, Minneapolis resident) with the dependent variables of interest (support for flowering lawns pre- and post-informational intervention). The outcome variable was condensed from four-levels to two-levels (support and oppose), and levels of several predictor variables were condensed for analysis (Table 6). Two variables, sample park and use of lawns for organized sports, were excluded from both models to avoid problems with complete separation, which occurs when the values of the predictor are associated with only one outcome value. Responses with missing data were excluded, resulting in a total sample size of 383. We confirmed an absence of multicollinearity among predictor variables (VIF < 10). For all cases, Cook's D < 3.0. Cases with the highest Cook's D were influential because of unbalanced data and were not excluded. Potential predictors were assessed for significance ($p < 0.05$) within full models. Model fit was assessed by calculating classification rate, sensitivity, and specificity, as well as Nagelkerke's pseudo R^2 and Hosmer-Lemeshow test.

2.4.3. Perceived benefits and concerns

The responses to open-ended survey questions about benefits and concerns regarding flowering lawns were transcribed and then coded in Excel. Codes were developed using an iterative, open coding strategy that allowed themes to emerge from the words and phrases used by respondents (Rubin & Rubin, 2012). The emergent themes were analyzed using descriptive statistics.

3. Results

3.1. Socio-demographic and park use characteristics

A total of 537 park visitors completed all or part of the survey questionnaire (response rate 66.4%). Compared to the population of Minneapolis, a higher proportion of survey respondents were white, had completed a bachelor's degree or more, were 25–44 years old, and lived in a household with children (Table 3). These differences may reflect response bias, different rates of park use between demographic groups, or both.

Table 3
Sociodemographic characteristics among survey respondents. Valid percentages shown due to missing data.

	Study Parks	Minneapolis
Race/Ethnicity (n)	(503)	(399,950)
American Indian/Alaska Native	3.0%	1.2%
Asian or Pacific Islander	3.4%	6.0%
Black or African American	15.5%	18.0%
Hispanic/Latinx	4.4%	10.0%
Other Race/Ethnicity	3.6%	0.1%
Two or More Races	6.2%	4.4%
White Alone	64.0%	60.3%
Educational Attainment, ages 25+ (n)	(443)	(267,800)
Less than high school	2.3%	11.4%
High school diploma or GED	9.0%	16.6%
Some college/assoc. degree	25.7%	24.6%
Bachelor's degree	35.2%	28.9%
Graduate or professional degree	27.8%	18.5%
High school or higher	97.7%	89.0%
Bachelor's or higher	63.0%	47.7%
Age, only 18+ (n)	(496)	(319,960)
18–24 years	13.7%	17.3%
25–34 years	33.9%	27.7%
35–44 years	23.6%	16.8%
45–54 years	13.5%	14.6%
55–64 years	8.5%	12.6%
65–74 years	5.8%	6.7%
75 years and older	1.0%	4.3%
Children in household? (n)	(521)	(169,803 households)
Yes	55.9%	23.9%
Postal code includes or borders park (n)	(505)	–
Yes	59.4%	–
Live in Minneapolis (n)	(499)	–
Yes	85.4%	–

Table 4
Park use frequency and type.

Survey item	%
Visit frequency at sample park (n)	(528)
Daily	23%
Weekly	43%
Monthly	20%
Annually	15%
Visit frequency at other parks (n)	(537)
Daily	24%
Weekly	51%
Monthly	18%
Annually	5%
Daily	2%
Uses of lawn areas (n)	(530)
Walking	77%
Sitting	48%
Sports, informal	38%
Picnic	37%
Sports, organized	11%
Dog	2%
Running	2%
n/a	6%

In terms of park use characteristics (Table 4), a majority of survey respondents reported visiting the park where they were surveyed or other local parks once a week or more often. Across all parks, walking across grassy areas was the most common use of lawns, followed by sitting.

3.2. Level of support

A substantial majority of respondents at all four parks supported

Table 5
Comparison of (1) support for flowering lawns and (2) perceptions of bees, pre- & post-informational interventions. McNemar's paired proportions test was used to test for significant differences (*p < 0.5, *** < 0.001).

Survey item		Pre	Post
Support for or opposition to flowering lawns in parks (n = 502)	Strongly support	55.2%	68.1%***
	Moderately support	42.0%	27.3%***
	Moderately oppose	2.4%	3.2%
	Strongly oppose	0.4%	1.4%
	Support	97.2%	95.4%***
	Oppose	2.8%	4.6%***
Perceptions of bees (n = 478)	Like	54.8%	55.4%
	Tolerate	31.0%	32.4%
	Dislike	14.2%	12.1%*

creating flowering lawns in parks, both before and after receiving information that flowering lawns were intended to provide forage for bees (Table 5, Fig. 3). Following the informational intervention, opposition to flowering lawns rose by 1.8 percentage points to 4.6% (McNemar's chi-sq = 3.3684, df = 1, $p < 0.05$). At the same time, strong support increased by 12.9 percentage points (McNemar's chi-sq = 31.325, df = 1, $p < 0.001$), indicating that the informational intervention had a polarizing effect on participants who initially expressed moderate support. The pattern of polarizing support was observed at all parks.

3.3. Variables associated with support

Prior to the informational intervention, participants with positive perceptions of the appearance of flowering lawns and of bees were more likely to support flowering lawns (Table 6). Conversely, likelihood of support decreased with age. Post-informational intervention, liking the look of flowering lawns and liking bees remained statistically significant. In addition, participants who visited the sample park weekly or more were more likely to support flowering lawns. Participants who reported that the presence of flowering lawns would increase their level of concern about bee stings were less likely to support them. While these results are suggestive, they should be interpreted carefully. The unbalanced data led to high odds ratios, large confidence intervals, and low specificity for the pre-information model. The post-support model achieved higher specificity and classification rate because of a higher number of oppose cases.

3.4. Perceived benefits and concerns

3.4.1. Aesthetics

Aesthetics was the most frequently mentioned benefit across all parks (Table 7). Participants said that flowering lawns were "aesthetically pleasing" (Participant M477), "are beautiful!" (K318) or "make it look more attractive" (W325). Moreover, 96.5% of participants strongly or moderately agreed with the statement *I like the way flowering lawns look* (Table 8). Some participants explicitly connected the appearance of flowering lawns to individual and community well-being (e.g. "increase the beauty, make people happy" K166). At Willard Park in particular, several respondents believed that aesthetic benefits would reach beyond the park and would demonstrate care (e.g. "make our neighborhood look nice" W325 and show "interest in caring for our neighborhood" W171).

Aesthetics were also mentioned as a concern by 5% of respondents. Some of these were personal concerns that flowering lawns may grow

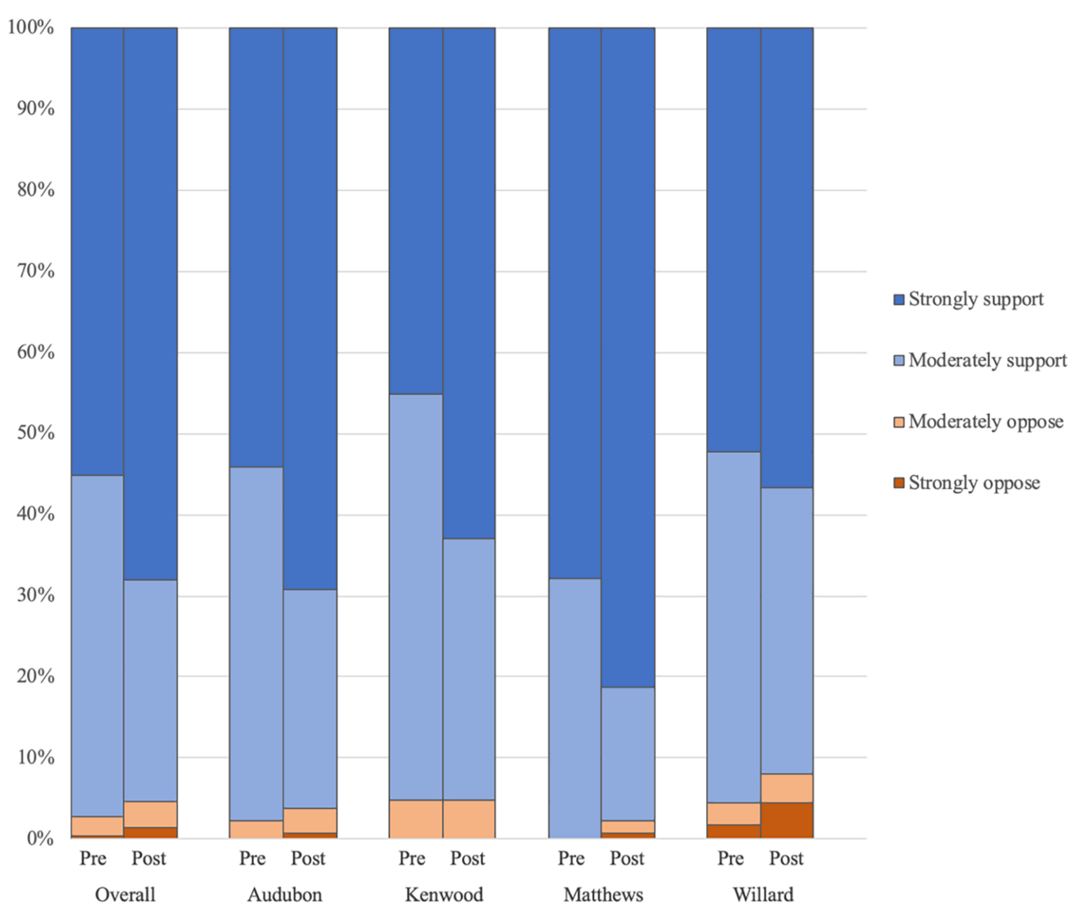

Fig. 3. Support for flowering lawns pre- and post-informational intervention explaining that flowering lawns were designed to support bees.

Table 6
Factors associated with support for flowering lawns in parks in logistic regression models, before and after the informational intervention explaining that flowering lawns were designed to support bees.

	Support (pre-information)			Support (post-information)		
N = 387	CI 2.5%	OR	CI 97.25%	CI 2.5%	OR	CI 97.25%
Park Use Variables						
Visit sample park – daily or weekly	0.41	2.28	13.32	1.69	9.44*	77.89
Visit other parks – daily or weekly	0.38	2.38	13.91	0.85	5.05	34.45
Lawn use						
Walk	0.07	2.01	32.61	0.01	0.27	4.69
Sit	0.02	0.46	4.20	0.26	3.11	33.57
Picnic	0.09	0.98	12.87	0.05	0.67	7.46
Sports, informal	0.06	0.68	7.57	0.09	1.01	10.99
Other	0.09	1.35	48.19	0.02	0.35	13.39
No Use	0.02	1.37	54.03	0.01	0.53	18.36
Perceptions of flowering lawns (FL)						
Like the way FL look	7.34	76.82**	1279.92	8.16	85.85**	1705.80
Would not avoid area with FL	0.43	2.57	14.42	0.05	0.38	2.07
Perception of bees & bee stings						
Like, tolerate, or dislike bees						
Like bees (pre)	1.95	14.72*	136.07	–	–	–
Tolerate bees (pre)	0.99	6.86	61.08	–	–	–
Like bees (post)	–	–	–	12.24	209.31**	9878.48
Tolerate bees (post)	–	–	–	0.93	5.43	40.38
Allergy to bee stings	0.12	0.63	4.05	0.09	0.40	1.76
Somewhat to very concerned about stings while at park	0.47	5.70	254.99	0.57	3.21	23.52
Concern about stings at park with FL						
More concerned with FL	–	–	–	0.01	0.08*	0.48
Less concerned with FL	–	–	–	0.02	0.29	9.27
Individual characteristics						
Age	0.85	0.91**	0.97	0.86	0.94	1.00
Race						
Black or African American	0.48	5.55	104.17	0.30	3.00	41.37
Other	0.25	2.14	53.97	0.08	0.60	4.89
Education – highest level completed						
High school or equivalent	0.54	31.26	2817.30	0.56	26.25	1220.72
College or assoc. degree	0.63	23.26	591.64	0.50	20.72	774.32
More than college	0.75	38.86	1715.83	0.57	39.74	3932.98
Child in household	0.19	1.19	7.61	0.10	0.59	3.03
Postal code includes or borders park	0.04	0.44	3.40	0.22	1.29	7.26
Minneapolis resident	0.02	0.57	10.58	0.01	0.13	1.67
Classification rate		96.5%			98.7%	
Sensitivity (true positive)		97.9%			99.5%	
Specificity (true negative)		72.7%			80.0%	
Pseudo R^2 – Nagelkerke		0.37			0.50	

Reference categories: Visit sample park = Monthly or less; Visit sample other = Monthly or less; Like look of FL = Disagree; Perceptions of bees (pre/post) = Dislike; Concern about stings while at park = Somewhat to Very concerned; Concern about stings at park with FL = No more or less concerned; Race = White; Education = Did not complete high school.
$^{*}p < 0.05$; $^{**}p < 0.01$.

Table 7
Five most commonly mentioned perceived benefits of and concerns about flowering lawns.

Benefits (n = 393)		Concerns (n = 383)	
Theme	%	Theme	%
Aesthetics	53%	No concern	56%
Bees	24%	Reduced use	10%
Pollinators/pollination	12%	Bees	9%
Biodiversity	9%	Unsure	9%
Good for environment	7%	Fragility of flowering lawns	6%

unevenly, “might appear like weeds” (K133), or that “if it's not well maintained, [it] could look trashy” (A345). In other cases, respondents expressed concern that *other* park visitors might object to the way flowering lawns look. For example, one participant wrote “people may think they are unkempt” (M47) and another said, “I wouldn't have any [concerns]; some people might think its weeds, if they didn't know” (A080).

3.4.2. Bees and pollinators

Even before the informational intervention, participants frequently connected flowering lawns with bees, expressing both positive and negative perceptions. Bees were the second most common benefit listed by participants (Table 7). Examples of responses include “helping bees” (W163), “flowering lawns can add a food source for bees” (M056), and “potential to increase declining bee populations” (A077). Furthermore, roughly half of respondents indicated that they like bees, and an additional third said they tolerate bees (Table 8). The informational intervention about the differences between bees and wasps led to a small, but statistically significant decline in the proportion of people who disliked bees.

Bees were also mentioned as a concern, though less frequently (Table 7). Some participants stated a general concern about “bees and other insects” (K284), while others specifically mentioned the risk of bee stings. It was common for participants to qualify their concern

Table 8
Descriptive statistics for key survey items.

Survey item		%
"I like the way they look" (n = 523)	Strong agree	59.8%
	Moderately agree	36.7%
	Moderately disagree	2.9%
	Strongly disagree	0.6%
"I would avoid an area with a flowering lawn" (n = 522)	Strong agree	10.2%
	Moderately agree	15.9%
	Moderately disagree	27.8%
	Strongly disagree	46.2%
Allergy to bee sting, personal or someone in household (n = 519)	Yes	17.1%
	Not sure	12.3%
	No	70.5%
Level of concern about stinging insects while at a park (n = 513)	None	43.9%
	A little	39.6%
	Somewhat	11.1%
	Very	5.5%
Change in level of concern about stinging insects at a park with flowering lawn (n = 510)	Significantly less	3.9%
	Slightly less	3.1%
	No more or less	65.9%
	Slightly more	22.2%
	Significantly more	4.9%

about stings by expressing uncertainty (e.g. "maybe bee stings?" K117) or by saying that they believed stings were not common (e.g. "stings from stepping/sitting on a bee…though it is probably unlikely" M177). The question about potential concerns occurred before the informational intervention that explained flowering lawns were designed to support bees, and more participants may have mentioned bees as a concern if the order had been reversed. Post-informational intervention, nearly three-fourths of participants said that flowering lawns would not increase their level of concern about stinging insects (Table 8).

Pollinators/pollination was the third most frequently mentioned benefit (Table 7). While this theme sometimes overlapped with the *bee* theme, respondents often mentioned pollinators in a general way, without mentioning bees specifically (e.g. "food for pollinators, increase in pollinator populations" A346).

3.4.3. Other emergent themes

Biodiversity was the fourth most commonly mentioned benefit (Table 7). Responses included "increased biodiversity allowing for a wider range of insects/small animals to live in the park" (M206) and "maybe more native or more diverse grass culture" (M070). A similar, but more generalized category of *good for the environment* also emerged. For example, one participant stated that flowering lawns were "eco-friendly" (K416) and another responded that flowering lawns would provide "ecosystem services!" (M376).

When asked about concerns, over half of participants gave responses such as "none!" (M019), "nothing" (W153) or other replies that indicated that they did not have any concerns about flowering lawns. Among respondents who articulated a specific concern, a possible reduction in recreational use of park lawns was the most frequently mentioned. One respondent said, "perhaps people think they look nice and thus avoid using them" (A438). Other concerns were specifically related to sports uses: one participant said flowering lawns were "not as friendly for sports" (K039) and another was concerned that there may be "less room for frisbee…?" (K269). Participants also expressed concern that even if flowering lawns could be used the same as traditional lawns, park visitors might not know this and could choose to avoid those areas. On a related point, several participants expressed concern about the fragility of the flowering lawns themselves and that they could be damaged by regular park uses. For example, one participant was concerned about "crushing the flowers when walking on them" (M364) and another wrote that "if flowers get picked + they die + no more pollen for bees" (K394).

Lastly, participants' responses frequently reflected uncertainty, ranging from a low degree (e.g. "attracts bees?" W543) to a high degree of uncertainty (e.g. "No clue" K312), suggesting that many participants were unfamiliar with flowering lawns as a concept.

4. Discussion

Given that aesthetic preferences play a dominant role in shaping urban landscapes (e.g. Blaine et al., 2012; Nassauer, 1995; Nassauer et al., 2009; Robbins, Polderman, & Birkenholtz, 2001), it was not surprising that liking the appearance of flowering lawns was associated with increased likelihood of support. However, because flowering lawns do not share many of the valued features of traditional lawns, namely, uniformity, greenness, or exclusion of non-turfgrass species (Alumai et al., 2010; Byrne, 2005; Cheng et al., 2008; Robbins and Sharp, 2003; Yue et al., 2017), nor the tall vegetation and structural diversity valued in urban meadows (Lindemann-Matthies & Bose, 2007; Southon et al., 2017a), we were surprised that nearly all respondents reported liking the way flowering lawns look.

Several scholars have described a dominant cultural preference for uniformity in lawns in Western landscape traditions (e.g. Byrne, 2005; Ignatieva et al., 2015; Robbins & Sharp, 2003). However, there is growing evidence from Europe and North America suggesting that both public preferences as well as extant lawn flora may be more heterogeneous than previously thought. For example, in the U.K., Southon et al. (2017a) found increasing public acceptance of urban meadows, which are less uniform and more colorful than traditional lawns. Choice experiments in Switzerland revealed preferences for meadows that were highly diverse in terms species, vegetation height, and leaf forms (Lindemann-Matthies & Bose, 2007). In the U.S., Graves, Pearson, & Turner (2017) found public preferences that favored floral abundance and color diversity in forest understory vegetation. In addition to heterogenous preferences, several studies have documented substantial species diversity in existing lawn flora in the U.S. (Lerman & Milam, 2016; Wheeler et al., 2017), the U.K. (Thompson et al., 2004), and France (Bertoncini, Machon, Pavoine, & Muratet, 2012).

While the questionnaire did not ask specifically about color, several responses to open-ended questions mentioned color as a benefit of flowering lawns. This is consistent with previous findings that urban residents value vegetation with bright colors (Hoyle et al., 2018; Lindemann-Matthies & Bose, 2007), though there may be 'threshold effect', whereby plantings are considered attractive only once they reach a certain minimum proportion of flower cover (Hoyle, Hitchmough, & Jorgensen, 2017). Furthermore, three of the most frequently mentioned benefits of flowering lawns were related to species diversity (*bees*, *pollinators*, and *biodiversity*) and previous research has found links between aesthetic appreciation and preferences for biodiversity (Lindemann-Matthies et al., 2010). In particular, there is growing evidence that laypeople use color diversity as a cue for estimating biodiversity (Hoyle et al., 2018; Lindemann-Matthies et al., 2010; Southon et al., 2017a,b). Examining the possible connections between aesthetic appeal and flowering lawns with varying levels of color and forb diversity is an exciting avenue for future research.

While concerns about the potential for flowering lawns to look 'weedy' or 'unkempt' were less frequent than positive perceptions, these concerns pose an important potential barrier to adoption. Defining which plant species qualify as a 'weed' is difficult because the boundaries of the category are socially constructed and shift over time (Falck, 2010). Following Falck (2010) we use the general definition that weeds are plant species considered to be undesirable by a social group in particular time and place. The presence of weeds often carries symbolic weight, conveying messages about care, neighborliness, and moral character (Blaine et al., 2012; Robbins & Sharp, 2003).

Research on turf management and lawn preferences frequently frames *any* non-turfgrass plant species as undesirable in lawns (e.g. Alumai et al., 2010 or Yue et al., 2017). Yet, inventories of the floral diversity in lawns suggests that spontaneously occurring forbs (or 'weeds') are quite common (Lerman & Milam, 2016; Thompson et al., 2004). This may suggest a gap between the idealized vision of a perfect lawn and the resources required to achieve it, perhaps resulting in a certain level of tolerance or even acceptance of 'weedy' lawns among some (Dahmus & Nelson, 2013) or growing acceptance of a 'messier' aesthetic (Hoyle, Jorgensen, Warren, Dunnett, & Evans, 2017). Alternatively, people may simply not notice floral diversity. In one example, diverse flower meadows were added to small public gardens in Paris, France, but unless the meadows were advertised or there was organized public involvement, most garden visitors did not notice a change in species diversity (Shwartz et al., 2014). Based on these findings, we propose that signage and educational programming could address potential pitfalls and increase perceived benefits of flowering lawns. Such public engagement efforts could help make flowering lawns more legible as intentional design choices rather than the result of neglect or lack of care. The legibility of alternative landscapes as designed and intentional plays a key role in social acceptance (Nassauer, 1995; Nassauer et al., 2009). Additionally, publicizing flowering lawns is likely to increase perceived biodiversity and the attendant social benefits.

However, polarization of support following the informational intervention suggests that the public engagement and messaging about flowering lawns must be framed carefully. A substantial minority of participants dislike bees, which held true following an informational intervention that emphasized differences between bees and wasps. Similarly, a majority expressed concerned about stinging insects when visiting parks. So, it is unsurprising that the informational interventions that focused on bees resulted in a slight increase in overall opposition. Alternative messaging might focus on the wider invertebrate diversity value of flowering lawns or perceived benefits that are less controversial, such as aesthetic benefits. Designing informational interventions around existing positive attitudes is likely to be more effective than interventions aimed at prompting substantial attitude changes (Heberlein, 2012). Future research could also test outreach efforts that are more in-depth or multimodal. Nevertheless, even the most effective messaging is unlikely to convince all skeptical park visitors. Selecting park areas with lower foot traffic for the creation of flowering lawns may be one way to ease persistent concerns about potential negative interactions with bees.

Prioritizing park areas with lower foot traffic for flowering lawn placement may also help address participants' fears that trampling could damage the vegetation. While trampling should be restricted during the month following initial seeding, flowering lawns can withstand walking and running once established. However, park visitors who are unfamiliar with flowering lawns may not be aware of this and could avoid flowering lawns out of well-intentioned, but ultimately overly cautious, concern. Locating flowering lawns in areas with lower foot traffic, at least to begin with, may minimize the potential for unintentionally changing park use patterns.

Older age decreased the likelihood of pre-information support for flowering lawns in parks. One possible explanation may be that older park visitors are more committed to the ideal of uniform, green turfgrass (Byrne, 2005). This would be consistent with findings that age was correlated with use of chemical fertilizers in private lawns (Carrico, Fraser, & Bazuin, 2013; Robbins et al., 2001), though a study of homeowners in the Minneapolis-St. Paul metropolitan area did not find that age was not related to fertilizer use (Martini et al., 2015). Furthermore, Southon et al. (2017a) found that in the U.K. older people showed stronger preferences for urban meadows with greater plant species diversity. The significance of age in the present study may also be related to our relatively young sample. Future research could target older adults to explore the role of age in perceptions of flowering lawns in more depth.

Based on our findings, we suggest several directions for future research. First, targeted sampling of populations likely to oppose flowering lawns could help elucidate variables associated with opposition. Second, as flowering lawns become fully established in park settings, future research can incorporate photos or direct observations of flowering lawns in the context of a park landscape and at different periods during the growing season. Third, future research should examine the role of additional variables that previous research suggests may influence landscape preferences, such as ecological knowledge and gender (Lindemann-Matthies & Bose, 2007; Southon et al., 2017a). Furthermore, the present study had a limited geographic scope and additional research should examine perceptions of flowering lawns in other cities and countries.

5. Conclusion

Urban green spaces are tasked with fulfilling multiple ecological and social goals ranging from stormwater infiltration and supporting biodiversity to offering opportunities for urban residents to exercise, socialize, and connect with nature (Hunter & Luck, 2015). The design of public green spaces must also be responsive to diverse stakeholder groups, who may perceive, experience, and value landscapes quite differently. The overwhelming degree of support for flowering lawns that we found among survey participants suggests flowering lawns can provide multiple benefits, including enhancing aesthetic appeal, increasing perceived biodiversity, and maintaining recreational use. Public land managers who wish to adopt flowering lawns to provide forage for bees can use our findings to craft public engagement messages that address concerns about flowering lawns and reinforce existing positive perceptions.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.landurbplan.2019.04.015.

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Applying 'action situation' concepts to public land managers' perceptions of flowering bee lawns in urban parks

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ABSTRACT

As urbanization increases, so do the demands on public parks to serve multiple aesthetic, recreational, and ecological functions. Decisions about vegetation selection and management on parkland are complex and must reconcile the values of diverse user groups. Public land managers serve a key role in this decision-making process, though their perspectives are not well understood. We apply Ostrom's 'action situation' concepts from the Institutional Analysis and Development (IAD) framework to four focus group discussions with public land managers about the possible implementation of flowering bee lawns (turf areas seeded with low-growing flowers) to support pollinators. The 33 participants represented 24 local park departments throughout the Minneapolis-St. Paul metropolitan area. The public land managers' descriptions highlight the intertwined roles that the public, elected officials, and maintenance staff play as stakeholders in vegetation change decisions. Participants' narratives also illuminate the dynamics governing the decision to adopt a novel vegetation type on parkland and the strategies public land managers use to negotiate these situations. The anticipated prevailing public opinion of flowering bee lawns varied across communities, yet there was similarity across park systems in the kinds of tensions and dynamics they expected (e.g. pressure to reduce maintenance costs, growing public concern for bee conservation, public fears of bee stings). They responded with three strategies; most common was an active effort to educate the public and elected officials. In contrast, some advocated a more discreet approach, experimenting with flowering lawns at low-visibility sites where the public would be unlikely to notice. Finally, a third approach, not mentioned as frequently, was to promote flowering lawns as an effort to reduce mowing or the use of herbicides. Our findings shed light on public land managers' understandings of the complex socio-ecological landscape that they must navigate to effect vegetation change.

1. Introduction

Urban green infrastructure on public land is essential for ecological function (Derkzen et al., 2015; Mexia et al., 2018) and human well-being (Chiesura, 2004; van den Bosch and Sang, 2017). Turfgrass lawns are ubiquitous on urban parkland throughout North America, Europe, and elsewhere (Hedblom et al., 2017; Ignatieva et al., 2015; Stewart et al., 2009; Wheeler et al., 2017). Rooted in centuries-old Western landscape design traditions, grass lawns have a long history as material manifestations of orderliness, mastery over nature, social status, and moral virtue (Blaine et al., 2012; Byrne, 2005; Nassauer et al., 2009; Robbins and Sharp, 2003). In the USA in particular, the famed Fredrick Law Olmsted and other early landscape architects left a legacy of parkland with large expanses of lawns that is still visible today (Cranz, 1982).

The potential for lawns to affect ecosystems positively or negatively is largely determined by management practices, which can vary widely (Wheeler et al., 2017). High input lawns maintained with herbicides, fertilizers, irrigation and frequent mowing have high aesthetic value (Ignatieva et al., 2017; Yang et al., 2019; Yue et al., 2017), but result in ecosystem disservices, such as intensive water use, nutrient runoff, and low species diversity (Fissore et al., 2012; Robbins and Sharp, 2003). Low-input lawns reduce fertilizer use and mowing (Hugie and Watkins, 2016) and often contain spontaneous species that can provide forage for pollinators (Larson et al., 2014; Lerman and Milam, 2016), though they have a limited role as reservoirs or corridors for native species (Wheeler et al., 2017). Globally, there is increasing interest in lawn alternatives to reduce ecosystems disservices and to support insect pollinators and biodiversity more broadly. These alternatives include, for example, grass-free forb-only lawns (Smith et al., 2015) and 'rough grass' in the

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Table 1
Comparison of key characteristics of lawns, flowering lawns, and other lawn alternatives (Modified from Ramer, Nelson, Spivak, Watkins, & Wolfin, 2019; Ramer, Wolfin, et al., 2019) by Joseph Nowak III. Note: (a) Table entries are brief summaries rather than comprehensive definitions. There can be variation in each category. (b) Flowering lawns, urban meadows, and native grasslands tend to be substantially better sources of bee forage relative to traditional turf lawns.

	TRADITIONAL TURF	BEE LAWN	URBAN MEADOW	NATIVE PRAIRIE
DESCRIPTION	Managed for turfgrass species, though without herbicides, may have unintentional forb spp. (Ignatieva, Eriksson, Eriksson, Berg, & Hedblom, 2017)	Mix of low-input turfgrasses and low-growing forbs selected to provide bee forage (Lane, 2016)	"Naturalistic, unmown grassland with or without flowering forbs." (Southon et al., 2017)	Dominated by grasses, often with diverse assemblage of forbs. (Blair, Nippert, & Briggs, 2014)
VEGETATION HEIGHT	5-11cm (Cornell University, 2018)	5-11cm (Lane, 2016)	5cm-100cm (Southon et al., 2017)	15cm-300cm (Blair, Nippert, & Briggs, 2014; Oregon State University, 2018)
MOWING FREQUENCY	1-6/month (Cornell University, 2018; Yue et al., 2017)	1-3/month (Lane, 2016)	1/month to 1/year (Southon et al., 2017)	0-2/year (Minnesota Department of Natural Resources, 2004)

UK (Hitchmough, 2009), urban flower meadows and naturalistic grasslands in France (Shwartz et al., 2014), the UK (Hitchmough, 2004; Southon et al., 2017), Sweden (Ignatieva, 2017), USA (Helfand et al., 2006), and China (Jiang and Yuan, 2017; Yang et al., 2019). Despite this growing interest, while developing park design concepts, decisionmakers must balance the potential ecological benefits of lawn alternatives with the interests of diverse stakeholder groups regarding recreational uses, aesthetic preferences, and maintenance requirements (Madureira and Andresen, 2014). Public land managers are key actors shaping the adoption of alternatives and additional research is needed to better understand managers' perspectives (Barnes et al., 2018; Shams and Barker, 2019). Here, we examine public land managers' descriptions of how they would navigate the adoption of flowering bee lawns in public parks to support bee pollinators.

1.1. Flowering bee lawns

As a general concept, flowering bee lawns are composed of a mix of turfgrasses and low-growing flowers, kept short by mowing and designed to provide high-quality bee forage (Ramer, Nelson, Spivak, Watkins, and Wolfin, 2019). The forb species suitable for flowering lawns will vary by climate, but they must be able to survive mowing disturbances, compete with (but not outcompete) turfgrasses, and bloom at low heights as well as provide bee forage. As an example, flowering lawn trials in the Upper Midwest of the USA contained self-heal (*Prunella vulgaris*), creeping thyme (*Thymus serpyllum*), Dutch white clover (*Trifolium repens*), and ground plum (*Astragalus crassicarpus*) mixed with Kentucky bluegrass (*Poa pretensis*) or fine fescue (*Festuca* spp.) grasses (Wolfin, 2020).

Flowering lawns differ from other lawn alternatives in important ways (see Table 1). While low-input lawns can support a diverse assemblage of pollinators (Larson et al., 2014; Lerman and Milam, 2016), preliminary research suggests that flowering lawns—with forb species deliberately selected for their forage characteristics—can support still higher bee diversity (Wolfin, 2020). Furthermore, flowering lawns are mowed more frequently than meadows or other taller vegetation, which preserves open sightlines as well as recreational uses such as walking. Grass-free lawns—as the name suggests—do not contain grasses, reducing mowing by half, but leading to an uneven walking surface (Smith and Fellowes, 2015).

1.2. Urban parks & public land managers

Urban parkland can provide a wide array of environmental and social benefits in cities, such as stormwater infiltration, erosion control, carbon sequestration, biodiversity, aesthetic benefits, recreational uses, and improved mental and physical health (Chiesura, 2004; Madureira and Andresen, 2014; Mexia et al., 2018). While many of these functions may successfully co-exist, decisionmakers must recognize potential conflicts and carefully weigh tradeoffs during the process of designing parks and selecting park vegetation (Madureira and Andresen, 2014). There is considerable research focused on park visitor preferences to inform these decisions (e.g. Hoyle et al., 2017a; Jiang and Yuan, 2017; Lindemann-Matthies et al., 2010; Southon et al., 2017; Todorova et al., 2004). However, public land managers have received less attention in the literature despite their crucial role.

What is a 'public land manager'? Drawing on Jansson and Lindgren (2012), we employ a definition of landscape management that encompasses all aspects of developing and maintaining urban greenspace. Public land managers are engaged in the "technical and biological aspects, but also human relations and organizational aspects" (p.142) of park management. They help to bridge multiple levels and timescales of management, including the strategic level that involves formulating longer-term goals as well as the operational level that involves day-to-day maintenance.

Recent research has examined public land managers' vegetation preferences (Barnes et al., 2018; Hofmann et al., 2012; Hoyle et al., 2017b; Nam and Dempsey, 2019; Özgüner et al., 2007; Shams and Barker, 2019) and management approaches (Lindholst et al., 2018; Randrup et al., 2017; Randrup and Persson, 2009). We seek to contribute to this literature by applying concepts from Ostrom's Institutional Analysis and Development (IAD) framework to examine the action situations land managers must navigate to adopt lawn alternatives, such as flowering lawns.

1.3. Ostrom's IAD framework & action situations

Ostrom's IAD framework is a powerful tool for analyzing the governance of public goods and common-pool resources at multiple scales (Ostrom, 2011). It has been used in wildly diverse contexts such as rural soil conservation in Ethiopia (Nigussie et al., 2018), urban forests in Switzerland (Wilkes-Allemann et al., 2015), and waste governance in Mexico (Jiménez-Martínez, 2018).

The 'action situation' is at the core of the IAD framework. It highlights the critical elements involved in resource governance and the rules that configure the interactions between them (Ostrom, 2011). The main elements include the actors involved in management, their roles, and the range of actions they may, must, or must not take. The action situation also emphasizes what information must be shared or kept secret, the ability of an actor to take action with or without prior permission from others, shared understandings of the kinds of resources or geographic areas that can and cannot be used, and any rewards or penalties for certain actions.

Here, we extend the IAD framework to urban parkland management. While not a traditional common-pool resource, urban greenspace is increasingly theorized as a form of commons (Bravo and Moor, 2008; Foster, 2011; Parker and Johansson, 2011). First, it is difficult to exclude people from using public parkland, fulfilling the *non-excludability* criteria of common-pool resources. Second, park use is *rivalrous* because overuse and crowding can reduce the ability of other park visitors to enjoy the resource. Furthermore, the physical design of parks, such as built infrastructure and the types of vegetation, can enable or preclude particular uses of parkland. For example, it is difficult to play soccer amid restored prairie and bird-watching is less successful on a playground. There are, of course, some distinctions between urban parklands and the type of common-pool resources from which Ostrom's work emerged. Notably, park visitors' livelihoods do not depend on use of the resource, the group of resource users is not strictly bounded, and many park visitors use the resource without taking part in the management (Parker and Johansson, 2011). Furthermore, rather than a collective management arrangement, government is primarily responsible for the planning, design, and maintenance of parkland in our study, though often with some degree of public participation. Despite these differences, the IAD framework remains a useful lens to analyze the dynamics actors must navigate to manage parklands as a common resource.

1.4. Research questions

We apply the action situation to public land managers' descriptions of the anticipated benefits and challenges of adopting flowering bee lawns. This close reading can shed light on public land managers' understandings of the complex socio-ecological landscape that they must navigate to effect vegetation change. In particular, we ask:

- What are the action situation elements and rules that shape the decision of whether public land managers might implement flowering bee lawns?
- How do land managers think strategically about the implementation of an alternative vegetation type, in particular, flowering bee lawns?

Fig. 1. Forb species in trial flowering lawns in Upper Midwest USA: (a) *Trifolium repens*, (b) *Prunella vulgaris*, (c) *Thymus serpyllum* and (d) *Astragalus crassicarpus*. Photos byUniversity of Minnesota Bee Lab.

Table 2
Guiding Questions for Focus Groups Discussions.

1	*What are some of the different kinds of vegetation you and your staff maintain?*
2	*What vegetation management challenges do you encounter in your day-to-day work?*
3	*What interactions with pollinators do you (or your staff) have during your work in the parks, if any?*
4	*What benefits do you think flowering lawns could provide in the parks that you're responsible for? (List as a group, then individually rank top 3)*
5	*What concerns do you have about flowering lawns in the park you're responsible for? (List as a group, then individually rank top 3)*
6	*From your perspective, what do you think could be challenges for implementing or establishing flowering lawns? (Are the challenges similar to the ones you find with implementing other types of vegetation? Are there challenges with implementation that would be unique to flowering lawns?)*
7	*What maintenance challenges do you think there could be with flowering lawns? (Are these maintenance challenges similar to the ones you'd have with other types of vegetation? Are there challenges with maintenance that would be unique to flowering lawns?)*
8	*How would you suggest the park deal with these implementation or management challenges?*
9	*Are there other important factors that we haven't discussed yet?*
10	*If you had one minute to give advice to the University of Minnesota Bee Lab about how to encourage cities or counties to create more flowering lawns, what would you say?*

2. Methods

As part of a larger interdisciplinary flowering lawn research project that also investigated bee diversity and park visitor perceptions (Ramer, Nelson, Spivak, Watkins, and Wolfin, 2019), we conducted focus group discussions with public land managers in the Minneapolis-St. Paul (MSP) metropolitan area of Minnesota, USA. We chose to use focus groups because they are useful for providing an in-depth understanding of a topic embedded in a specific context and discovering key factors influencing participants' perception of a topic (Krueger and Casey, 2015).

2.1. Site description

The MSP region—with a population of 3.1 million people—is located in the Upper Midwest and is characterized by a temperate continental climate with warm summers and cold winters. Representing nearly 10 % of the total land area, the region's 74,740 ha (184,690 ac) of parkland supports vegetation ranging from highly-manicured turf to minimally-managed forest, though detailed data regarding vegetative cover are not available. The parkland is spread across a patchwork of 182 municipal governments, seven county parks departments, and one regional park system (Metropolitan Council, 2019a, 2019b). The local government units vary widely in terms of population, land area, amount of parkland, budget size, governance structure, and the number of staff dedicated to parkland management (Metropolitan Council, 2019a).

2.2. Recruitment and data collection

We recruited public land managers from regional and county park systems as well as municipalities with populations >1,000. Managers with publicly-available contact information (n = 104) were recruited in random order until we obtained five to ten participants for each focus group, reflecting ideal group size (Krueger and Casey, 2015). Thirty-three public land managers representing twenty-four park systems participated in a total of four focus group discussions.

Focus groups were held at the University of Minnesota Bee Lab during September 2018 and each discussion lasted approximately 1–1.5 h. Because it is a relatively new concept for most participants, each focus group began with a brief definition of flowering lawns and an overview of the recommended forb species for the region, accompanied by photos (Fig. 1). A discussion guide of ten key questions was used to facilitate the focus groups, which provided structure for the discussions while allowing the flexibility to explore emergent themes (Table 2).

2.3. Data analysis

All focus group discussions were audio-recorded, transcribed, and then analyzed using NVivo version 12. A semi-open, iterative coding strategy was used to code for action situation concepts vis-à-vis public land managers (see Appendix A). First order codes were organized by the *positions* that participants identified as key stakeholders: the public, elected officials, maintenance staff, and managers themselves. Second order codes were then organized around the range of *actions* that actors in each position may, must, or must not take. Sub-codes reflect emergent themes (see Appendix B).

Focus group methodology is not designed to measure prevalence of a particular view in a population, therefore we do not report frequency counts or percentages to avoid inappropriate attempts to project patterns to the population or assumptions about the relative importance of themes based on frequency alone (Krueger and Casey, 2015). Instead, we seek to offer an exploratory analysis of public land managers' perspectives on flowering lawns in the MSP metropolitan area.

3. Results

3.1. Action situation

When asked about anticipated benefits and challenges of adopting flowering bee lawns in their respective park systems, participants described action situations defined by three stakeholder groups: the public, municipal staff, and elected officials. While participants anticipated widely differing degrees of support for flowering lawns in their own communities, participants predicted remarkably similar dynamics in the decision-making processes.

3.2. The public

Land managers described an intense pressure to be responsive to public input on vegetation and identified complaints as a primary factor shaping maintenance practices. For example, one participant reported that despite a department-wide goal to reduce herbicide use, they will spray certain lawn areas if they receive public complaints. Another participant described his department's biggest challenge as the "public calling in to say 'this is ugly'… and everyone has a different opinion on what it should look like and what would be nice" (FG1), reflecting the difficult task of balancing conflicting opinions within a community.

Participants described substantial differences between communities in terms of public perceptions of vegetation. For example, public pressure had driven some participants to eliminate herbicide use altogether. Meanwhile, in other communities, public pressure had led participants to spray all park lawn areas. The way participants described their sensitivity to public complaints also varied. For example, one participant described tolerating complaints about a reduced mowing regime until community members eventually seemed to accept the change. However, others agreed that it took "just one call to the mayor" (FG2) or other top official to halt new management practices.

With respect to flowering lawns in particular, most participants predicted that park visitors would have divergent opinions. On the one hand, land managers anticipated public opposition based on fears of bee stings, the appearance, or the cost of implementation. For example, one participant predicted that park visitors would complain and say "'my kid is allergic, you can't have that [flowering lawns] in the park'" (FG4). Furthermore, participants feared that if park users assumed that the bee-friendly forbs were weeds, they might accuse park staff of neglect or "not doing their job"(FG4). Another participant summed up all of these concerns, saying "So while I think there are a lot of benefits to it, that's really a challenge we're gonna have to face: to spend city money to grow 'weeds' that are going to attract bees. That's three strikes against you" (FG4).

On the other hand, several participants described growing public support for pollinators and biodiversity generally. One participant reported "I had a voicemail this summer from cutting down our alfalfa 'cause we were doing weed management…This guy left me at least a forty-minute dissertation about pollinators and bees…" (FG1). Another described being surprised by the level of controversy and unfavorable newspaper coverage that emerged after maintenance staff mowed down a patch of milkweed (*Asclepias* spp.), the host plant for the monarch butterfly (*Danaus plexippus*). In a few municipalities, community groups had even volunteered labor and funds to install and maintain pollinator conservation projects, such as mason bee houses or pollinator gardens.

3.3. Elected officials

Public land managers must adhere to directives from elected officials, such as the mayor or city council members. However, the direction of influence is often two-way, as elected officials often rely on public land managers for recommendations when formulating policy. Furthermore, land managers can often exercise discretion during implementation.

All participants described pressure from elected officials to cut park maintenance budgets. Participants described mowing turf as the single greatest use of staff hours and a primary target for cost cutting. One participant explained, "We're always being challenged with doing more with less and, quite honestly, about the only way in the summer we're gonna be able to cut staff is if we can cut a hundred acres out and take a mower out of service" (FG1).

While participants identified cost reduction as the dominant pressure from elected officials, this concern could be superseded by public complaints. For example, one participant recounted that the city council sought to steeply reduce the budget in the wake of the 2008 recession and eagerly agreed to his proposal to discontinue mowing in several low-use park areas, but reversed course when they received complaints. The participant explained, "Even in that extreme example where we had a budgetary problem…council's position…was 'I don't care what we said or what we approved or what we told you we were going to do, go mow it! I don't want to hear it; I don't want to have that call again!'" (FG3)

Less frequently, participants described instances where elected officials directed land managers to seek ways to meet environmental goals, such as preventing erosion, reducing CO_2 emissions, or increasing biodiversity. Elected officials in some communities had adopted pollinator-friendly resolutions directing city agencies to protect and support pollinators (Appendix C contains examples). Several participants whose communities did not yet have pollinator-related resolutions expressed a perception that they are a growing trend, and they are "coming to everyone soon" (FG2).

3.4. Maintenance staff

Maintenance staff conduct the day-to-day tasks necessary for maintaining public parkland including turf mowing, applying fertilizers and herbicides, forestry activities, maintenance of ornamental plantings, invasive species control, and restoration plantings, though specific duties varied across municipalities. Often, staff also monitor site conditions and respond to public feedback in the field.

Participants described several staff-related barriers to adopting flowering lawns, including (a) anticipated opposition from maintenance staff, (b) difficulty of changing established routines, and (c) a knowledge and training gap. Some participants stated that many maintenance staff personally preferred the uniformly-green lawn aesthetic, and may actively resist the introduction of forbs into turf. Additionally, even if the staff did not object to flowering lawns, participants were concerned it would still be difficult to alter existing mowing and herbicide application routines. An exchange between three participants illustrates their past experiences with attempts to change management practices:

Participant A: *I've been on that path [reduced mowing] for years and gone so far as to actually staking out these no-mow areas…It serves no purpose. The mow crew, some of which because they're seasonal and inexperienced, they venture into those areas because they forgot that we haven't mowed them for years or it's their first time out. Or we have some staff…that are just compelled to mow—*

Participant B: *It looks like crap, that's what they say*.

Participant C: *It's the same thing [for us]…Planning [Department] puts together these mowing exhibits…and it's all color coded and you hand it to the maintenance staff, and you come back and this one section is mowed and I'm like, 'Well, why was that mowed? It's not supposed to be*.' (FG3)

Lastly, participants described staff as well-versed in turf management, but unfamiliar with the forbs recommended for flowering lawns, making it difficult for staff to monitor establishment or conduct spot control of invasive species without additional training. One participant described the challenge in financial terms:

my staff is for the most part professional turf experts, they're not [flowering lawn experts]. So, it's learning and education, and what's the first thing a city council member wants to cut every year in the budget? It's training. So then how do you develop a staff that can get it? (FG1)

The relative importance of these factors in each park system seemed to be mediated by variation in existing herbicide use and the degree of contracting out for maintenance tasks versus hiring staff directly. First, herbicide practices ranged from blanket use on all turf areas in some communities to a near ban of herbicides in others. Broadcast herbicide application is incompatible with flowering lawns, so for park systems in the former category, adopting flowering lawns would represent a substantial change in practices, adding complexity and room for error. Second, some participants represented smaller towns that did not directly employ maintenance staff, but rather contracted with private companies to maintain parkland. These communities were reliant on the offerings and expertise of private companies, shaping the ability of small towns to adopt new kinds of vegetation and practices.

3.5. Land managers: tradeoffs and strategic action

Public land managers must weigh tradeoffs of lawn alternatives, such as flowering lawns, in the face of uncertainty about cost, vegetation performance, and public perceptions in their communities. Land managers highlighted potential benefits including increased bee forage, positive public feedback, reduced maintenance time and cost (from reduced mowing, herbicides, and fertilizers), and increased environmental benefits (from reduced herbicides, fertilizers, and irrigation). Managers identified potential downsides as negative public comments, the perception of 'neglect of duty' resulting in loss of trust in the manager and/or the department, increased complexity of maintenance operations, and increased cost (for staff training, establishing bee lawns, and replacement if it is unsuccessful).

In the face of these possible tradeoffs, participants articulated three main strategies for adopting flowering lawns. The most common approach discussed by land managers was to educate stakeholders about flowering lawns to win advance support for the change. This would involve addressing anticipated concerns about aesthetics and risk of bee stings through signage, programming, staff training, newsletter announcements, and social media. One participant explained: "…the education piece will go a long way for the people who want to complain about all the weeds and… [to] just understand what we're trying to do… just getting out in front of it and get some good P.R. [public relations or publicity] on it before you implement it" (FG2), emphasizing the importance of a pre-emptive education campaign.

Many participants saw winning public support as key to including flowering lawns on parklands, more so than land managers' recommendations. One participant explained "Things get done if it comes from the public. If it comes from us [staff], it's not as successful" (FG3). Others focused more on winning the support of elected officials:

Participant D: *I think getting buy-in from council or an administrator for what you're doing and them giving you a little bit of time to get it established.*

Participant E: *I would agree, I would suggest that, for me anyway… making the time to communicate what we're going to do in this new initiative or get approval from the park board or council such that it was sanctioned and it didn't unravel for you after you made the investment to establish these areas.* (FG3)

However, others recognized that winning initial support from elected officials was no guarantee of ongoing support. A third participant added, "I've had issues even going that route, though. You know, the park commission says, "oh great" and [it] turns to a crap show later on because they [the residents] complain to the mayor or whoever" (FG3).

Once flowering lawns are established, several public land managers recommended ongoing education efforts such as incorporating signage as a signal that vegetation choices were intentional and not the result of neglect. This 'proactive education' strategy would seek to harness growing public concern over pollinator health and emphasize the benefits to bees. In doing so, participants believed that flowering lawns could be promoted as evidence of their departments' environmental innovation and leadership. Participants saw the formal pollinator-friendly resolutions as lending further institutional support.

In contrast, some participants advocated a more discreet strategy, in which flowering lawns would be implemented at low-traffic, low-visibility sites where the public would be unlikely to notice a change. Participants explained that this strategy would minimize the risk of complaints and allow for experimentation with management practices while still providing bee forage. Land managers also saw this strategy as leading to faster implementation because it would not depend on a potentially lengthy public discussion and municipal approval processes. One participant asked, "is it easier to ask for forgiveness or permission?" (FG4), clearly implying the former. Other land managers were more cautious and perceived their ability to implement changes without prior approval as limited. They cautioned that failing to seek permission could result in rebukes later on. One participant explained "you may be able to dodge that bullet and [beforehand] say, 'I am going to plug some of this stuff in here, let's give it a whirl, see what happens'" (FG4). Participants sometimes discussed this 'low-profile' strategy as a precursor to the 'proactive education' approach. When used in combination, the former could allow land managers to experiment with new vegetation and gather data. Later, they could use this to present a stronger case to the public and elected officials in the hopes of winning approval for wider-scale adoption.

A third proposed approach was to frame flowering lawns primarily as an effort to reduce mowing or the use of herbicides. One participant explained, "If you promoted this as a low-grow, low-maintenance type turf, as opposed to pollinator habitat—that's a secondary benefit instead of the primary benefit—then maybe you could avoid some of those [complaints]" (FG4). In this case, benefits to bees would be de-emphasized or elided altogether, to avoid triggering fears of bee stings. Instead, the financial costs and negative environmental impacts of traditional turf would be emphasized. This strategy was notably less popular; only two participants expressed interest in this strategy.

Regardless of approach, participants expressed a desire to have prepared talking points for responding to anticipated public complaints. Participants stated that information from trusted third parties, such as a research university, would provide additional authority to their education efforts. Furthermore, participants saw talking points as a way to reduce the burden of responding to complaints and to maintain a consistent message with the ultimate goal of shifting public perceptions over time.

4. Discussion

The present study builds on literature in three areas: applied insights for urban commons theory, the use of Ostrom's IAD framework, and the role of public land managers. First, the present study provides an empirical grounding for the emerging literature that theorizes urban public lands as commons (Bravo and Moor, 2008; Foster and Iaione, 2016; Shah and Garg, 2017; Steed and Fischer, 2008). Following Foster and Iaione (2019) and Parker and Johansson (2011), we seek to extend the considerable body of research inspired by Ostrom's work by applying action situations from the IAD framework to a relatively novel context: urban parks as commons.

Additionally, we build on research by Barnes et al. (2018) about the key role public land managers play in the adoption of more sustainable vegetation by demonstrating *how* they strategically navigate this role while embedded in a complex web of relationships with other actors. Furthermore, a close examination of public land managers' accounts allows us to elucidate the link between the elements and rules of the action situation, and the specific strategies that public land managers may employ to balance anticipated tradeoffs when considering the adoption of alternative vegetation.

Previous research in Germany and the UK suggests that public land managers tend to hold favorable views towards naturalistic vegetation styles in terms of the environmental impacts and the maintenance required, but adoption is constrained by the perceived dominance of public preferences for more formal styles (Hofmann et al., 2012; Hoyle, Jorgensen, et al., 2017; Nam and Dempsey, 2019; Özgüner et al., 2007; Shams and Barker, 2019). Similarly, our research found that public land managers viewed public preferences—particularly complaints—as a dominant influence in the decision-making process. This suggests that, as a group, land managers may be hesitant to adopt vegetation styles too far outside what they perceive as socially accepted norms. However, participants' accounts also revealed that sensitivity to public complaints varied among individuals. Future studies should examine land managers' tolerance of complaints, and whether this varies according to personal temperament, past experiences, or the level of support they believe they can count on from elected officials.

Our research suggest a few practical applications for the adoption of flowering lawns and other lawn alternatives, particularly for land managers in Minnesota and the Upper Midwest. First, participants reported wide variation in the extent of herbicide use on turf. Flowering lawns would represent a substantial change in management practices for turf managed with herbicides, but a relatively minor change for low-input turf. (However, this may vary by site and existing practices. For example, Ignatieva's (2017) research in Sweden indicates that establishing flower-rich meadows requires the removal of grass clippings to restrict fertility.) Avoiding a major change in practices would prevent the need for staff retraining, though it would not substantially reduce mowing costs. Other lawn alternatives such as grass-free lawns or meadows may be a better option if the main goal is to reduce mowing costs, though these alternatives come with other maintenance and staff training costs (Hitchmough, 2004; Hoyle, Jorgensen, et al., 2017; Smith and Fellowes, 2015).

Second, if flowering lawns are adopted, participants suggested education campaigns and on-site signage indicating that forbs are intentional in order to pre-empt complaints about perceived neglect or poor management. While park visitors frequently do not read interpretive signs, they do often notice them (Hall et al., 2010; Tubb and Tubb, 2003). Simply the presence of signage may function as a 'cue to care' that increases social acceptance of alternative vegetation (Nassauer, 1995, 2011; Nassauer et al., 2009).

Participants also identified external factors that could facilitate the adoption of flowering lawns on a larger scale, many of which are already beginning to emerge in Minnesota. For example, several nurseries and seed supply businesses are beginning to carry flowering bee lawn seed mixes containing the same forb species discussed with participants (Ramer, Wolfin, et al., 2019). Participants also underscored the benefit of having a trusted third-party source of information. Currently, the University of Minnesota is disseminating guidelines for flowering lawn establishment and providing sample education materials (Ramer, Wolfin, et al., 2019). Lastly, our participants highlighted the importance of having local or state legislation to encourage alternative vegetation. Since 2014, forty-four municipalities throughout Minnesota have adopted pollinator-friendly resolutions (Pollinate Minnesota, 2019). Furthermore, in 2019, the state legislature created the Lawns-to-Legumes program to provide education, design assistance, and cost-sharing for homeowners to convert their lawns to pollinator-friendly vegetation in priority areas for at-risk species (MN Board of Soil and Water Resources, 2019).

There are several limitations of our study. While focus groups can provide rich detail and key insights for a specific context, our participants were drawn from a narrow geographic area and we caution against overgeneralizing our findings to other contexts. Also, despite our efforts to randomize recruitment, there was likely a degree of self-selection bias in our sample, with managers interested in alternative vegetation more likely to participate. Lastly, our findings are based on the accounts of public land managers and solely reflect their perspectives. Future research that includes multiple stakeholder groups, such as elected officials or park visitors, would offer valuable additional insights.

5. Conclusion

Bee habitat and forage is a landscape-level ecological requirement. Targeting individual public land managers is a step in the right direction but may result in an uneven patchwork of habitat and nutritional sources across an urban ecosystem. For an effective expansion of habitat and forage, flowering bee lawns must become accepted as part of new social norms that value (or at least tolerate) alternatives to high-input turfgrass lawns. We must acknowledge that there are many factors driving interest in alternative vegetation, aside from a concern for bee conservation. The tension around limited municipal resources will likely continue as will pressure on urban greenspaces to provide multiple ecological benefits and recreational opportunities. Balancing these tradeoffs is a complex but critical task for managing urban public parklands in ways that promote both human wellbeing and ecosystem health.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Hannah Ramer: Investigation, Formal analysis, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Kristen C. Nelson:** Conceptualization, Validation, Supervision, Funding acquisition, Methodology, Formal analysis, Writing - original draft, Writing - review & editing.

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Appendix A. Action situation: the case of public land managers & vegetation management

Positions	*Public - includes individuals who come into contact with public land mangers through public meetings, phone calls, electronic communications, as individuals or part of an organized group, as park users or park volunteers.* *Elected Officials – includes mayor, city council members, and official boards or commissions that oversee parks and natural resources* *Maintenance Staff – includes staff responsible for day-to-day vegetation maintenance* *Public Land Managers – includes directors of park departments or public works departments, park maintenance managers, park planners, natural resource specialists, turf specialists, and city administrators or other staff responsible for managing parklands (all participants)*
Actions and choice rules	*Managers' understandings of the range of actions that actors in each position may, must, or must not take with regards to vegetation management (including public, elected officials, maintenance staff, public land managers)*
Information about actions and information rules	*Managers' understandings of the information regarding vegetation management that must or should be shared with actors in other positions or that must be held secret from others.*
Control over actions and aggregation rules	*The degree to which managers perceive they are able to make vegetation management decisions independently and the limitations on that ability from actors in other positions (public, elected officials, maintenance staff)*
Potential outcomes and scope rules	*Managers' understandings of the scale and geographic scope of outcomes that can be affected by particular actions.*
Net costs, benefits, and payoff rules	*The benefits and costs managers anticipate as a result of a specific vegetation management decision. Benefits and costs may accrue to any of the positions and/or the resource itself.*

Appendix B. Coding guide

Based on 'action situation' variables from Ostrom (2011) IAD framework, the first tier of codes is organized by the *positions* that public land managers identified as key stakeholders in vegetation decisions. The second tier is organized by managers' understandings of the range of *actions* that each position may, must, must not, or is likely to take.

1. The Public – *includes individuals who come into contact with public land mangers through public meetings, phone calls, electronic communications, as individuals or part of an organized group, as park users and park volunteers.*	
1a. Comments about vegetation	**1a-i. Complaints** – *vegetation types that receive complaints, to whom complaints are directed, how complaints are communicated* **1a-ii. Divergent public opinion** – *variation within and between cities* **1a-iii. Land managers' reactions** – *how land managers handle and respond to public comments (e.g. education, change in management, tolerate/ignore)*
1b. Anticipated reactions to flowering bee lawns	**1b-i. Support** – *anticipated reasons for and level of future support* **1b-ii. Opposition** – *anticipated reasons for and level of future opposition*
2. Elected Officials – *includes mayor, city council members, and official boards or commissions that have authority over parks and/or natural resources*	
2a. Flow of influence	**2a-i. Aggregation rules** – *the degree to which managers perceive they are able to make vegetation management decisions independently or need prior permission from elected officials* **2a-ii. Information rules** – *managers' understandings of information that must (or should) be shared with or held secret from elected officials*
2b. Articulated goals	**2b-i. Policy goals** *as described by elected officials as the basis of direction to public land managers* **2b-ii. Relative importance** – *if goals conflict, which is prioritized?*
2c. Anticipated reaction to flowering bee lawns	**2c-i. Support** – *anticipated reasons for and level of future support* **2c-ii. Oppose** – *anticipated reasons for and level of future opposition*
3. Maintenance Staff – *includes staff responsible for day-to-day vegetation maintenance*	
3a. Change in maintenance practices	**3a-i. Aggregation rules** - *Managers' perceptions of the degree to which maintenance staff will comply with managers' directions* **3a-ii. Barriers** *that inhibited change (Assets were also a possible category, but were not mentioned)*
3b. Anticipated reactions to flowering bee lawns	**3b-i. Support** – *anticipated reasons for and level of future support* **3b-ii. Opposition** – *anticipated reasons for and level of future opposition*
4. Public Land Managers – *includes directors of park departments or public works departments, park maintenance managers, park planners, natural resource specialists, turf specialists, and city administrators or other staff responsible for managing parklands (all participants)*	
4a. Weighing net benefits and costs	**4a-i. Benefits** *or rewards may accrue to any actors or the resource itself* **4a-ii. Costs** *or sanctions may accrue to any actors or the resource itself* **4a-iii. Uncertainty** - *information that would influence management decisions if known*
4b. Strategies – based on information rules, aggregation rules, scope rules, payoff rules	**4b-i. Proactive education approach** **4b-ii. Low-profile approach** **4b-iii. De-emphasize bees**

Appendix C. Examples of pollinator-friendly resolutions

Example 1: Dakota County, Minnesota

Resolution In Support Of Protection And Promotion Of Pollinators,

WHEREAS, bees and other pollinators are crucial to the survival and propagation of many plant species and are thus important to ecological and economic health; and

WHEREAS, many pollinators are threatened due to loss of habitat and other stressors in the environment that include exposure to pesticides, pathogens, and parasites; and

WHEREAS, the Rusty Patched Bumble Bee, whose current range includes much of Dakota County, has been officially listed federally as an endangered species; and

WHEREAS, recent research strongly indicates a link between insecticides that contain neonicotinoids and impacts to pollinator species; and

WHEREAS, the Dakota County Natural Resource Management System Plan identifies bees, butterflies and other pollinators and beneficial insect habitat as a Tier I wildlife management activity in parks and a priority in the management of regional greenways and conservation easements; and

WHEREAS, the Dakota County Board of Commissioners finds it in the public's interest to commit the County to a safe and healthy environment through implementation of practices that support pollinator species.

NOW, THEREFORE, BE IT RESOLVED, That the Dakota County Board of Commissioners hereby supports the implementation of practices that promote pollinator species in the development, care, and management of County owned and maintained properties and projects; and

BE IT FURTHER RESOLVED, That Dakota County will promote similar support for pollinator species when acting in partnership with other units of government, agencies, or entities; and

BE IT FURTHER RESOLVED, That Dakota County will seek to avoid, find reasonable alternatives to, and refrain to the greatest extent practicable from, the use of insecticides containing neonicotinoid compounds; and

BE IT FURTHER RESOLVED, That Dakota County will continue to promote and install pollinator friendly plantings when viable and appropriate with a preference for native species of a local ecotype which enhance habitat for native pollinators.

Adopted December 12, 2017

Example 2: City of shorewood

A RESOLUTION ENDORSING " BEE-SAFE" POLICIES AND PROCEDURES

WHEREAS, the Shorewood City Council and Park Commission have undertaken

several work sessions dedicated to the study and understanding of promoting a healthy natural environment through the reduction and elimination of harmful pesticides; and

WHEREAS, bees and other pollinators are integral to a wide diversity of essential foods including fruit, nuts, and vegetables; and

WHEREAS, native bees and honey bees are threatened due to habitat loss, pesticide use, pathogens and parasites; and

WHEREAS, recent research suggests that there is a link between pesticides that contain

neonicotinoids and the die -off of plant pollinators, including honey bees, native bees, butterflies, moths, and other insects; and

WHEREAS, neonicotinoids are synthetic chemical insecticides that are similar in structure and action to nicotine, a naturally occurring plant compound; and

WHEREAS, the City Council finds it is in the public interest and consistent with

adopted City policy for the City to demonstrate its commitment to a safe and healthy community environmentthroughtheimplementationofpestmanagementpracticesinthemaintenanceofthe

city parks, open spaces and city property.

NOW, THEREFORE, BE IT RESOLVED by the City Council of the City of Shorewood:

1 The City shall undertake its best efforts to become a Bee -Safe City by undertaking best management practices in the use of plantings and pesticides in all public places within the City.
2 The City shall refrain from the use of systemic pesticides on Shorewood City property including pesticides from the neonicotinoid family.
3 The City shall undertake its best efforts to plant flowers favorable to bees and other pollinators in the City's public spaces.
4 The City shall designate Bee -Safe areas in which future City plantings are free from systemic pesticides including neonicotinoids.
5 The City shall undertake best efforts to communicate to Shorewood residents the importance of creating and maintaining a pollinator -friendly habitat.
6 The City shall publish a Bee -Safe City Progress Report on an annual basis.

Adopted July 28, 2014.

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