

Prepared in cooperation with the Farm Service Agency, Natural Resources Conservation Service, and Honey Bee Health Coalition

Identifying Physical Characteristics and Functional Traits of Forbs Preferred or Highly Visited by Bees in the Prairie Pothole Region

Open-File Report 2022–1114

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By Stacy C. Simanonok and Clint R.V. Otto

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Conversion Factors

International System of Units to U.S. customary units

Multiply	By	To obtain
Length		
meter (m)	3.281	foot (ft)
meter (m)	1.094	yard (yd)
Area		
acre	4,047	square meter (m ²)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm ²)
acre	0.004047	square kilometer (km ²)

Abbreviation

USDA U.S. Department of Agriculture

Identifying Physical Characteristics and Functional Traits of Forbs Preferred or Highly Visited by Bees in the Prairie Pothole Region

By Stacy C. Simanonok and Clint R.V. Otto

Abstract

Establishing and enhancing pollinator habitat to support declining bee populations is a national goal within the United States. Pollinator habitat is often created through incentive-based conservation programs, and the inclusion of cost-effective forbs within the habitat design is a critical component of such programs. U.S. Geological Survey research from 2015 to 2019 identified forb species that (1) were preferred or highly visited by bees, (2) demonstrated high rates of establishment success, and (3) could be purchased at reduced cost. In this report, we enhance this past research by identifying common physical characteristics and functional traits of these cost-effective forbs so that land managers may have easy access to information on cost-effective forbs for new conservation plantings. This report highlights 22 forb species that were preferred and (or) highly visited by honey bees (*Apis mellifera* Linnaeus) or wild bees. Of the species evaluated for cost-effectiveness, most had less than average seed cost and greater than average apparent establishment rates. Several forb species were not considered cost effective because of bee avoidance, poor establishment, or high seed cost. Most forbs preferred or highly visited by bees were from the Asteraceae family and demonstrated a wide range of flower color. Forb species represented a range of wetland statuses from facultative wetland to upland, indicating that wetland and nonwetland habitat types represent areas where important floral resources for bees exist. Many forb species were in bloom from June to September, but our results showcase forb species that could be used in conservation projects seeking early- (June–July) or late-season (August–September) floral resources for pollinators.

Introduction

Pollinators, such as honey bees and wild bees, serve an important role in supporting agricultural systems, and insect pollination services are valued at \$15 billion annually in the United States (Calderone, 2012). With regional and global

declines of honey bees and wild bees (Gixti and others, 2009; Potts and others, 2010; Hellerstein and others, 2017), the Pollinator Health Task Force detailed three national goals for pollinator recovery in 2015 (Pollinator Health Task Force, 2015). One goal was to create or enhance 7 million acres of pollinator habitat by 2020. Given the importance of bees to the U.S. agrifood system and this national pollinator habitat goal, interest and demand within Federal, State, and local governments to create more pollinator-friendly plantings have increased. Pollinator habitat plantings heavily emphasize seeded forbs (defined as herbaceous, broadleaf plants that are not grasses), which provide floral resources for bees. Some commonly seeded forb species include *Rudbeckia hirta* L. (blackeyed Susan) and *Helianthus maximiliani* Schrad. (Maximilian sunflower) (Simanonok and others, 2022). One way pollinator habitat is created is through incentive-based conservation programs established under the U.S. Department of Agriculture (USDA) Farm Bill (U.S. Department of Agriculture, 2015). For example, within the Conservation Reserve Program, Conservation Practice-42 (Pollinator Habitat) is administered by the Farm Service Agency and specifies that plantings should contain a minimum of nine pollinator-friendly native forb species, including three species each from the early, middle, and late parts of the flowering season (Farm Service Agency, 2013).

Many land managers are tasked with selecting forbs to include in mixes designed for pollinator habitat; however, the high seed cost of certain forb-heavy mixes can make pollinator habitat conservation programs expensive and can deter individuals from including many forbs in their seed mixes. For example, a mix with nine forb species can cost five times more than a mix that contains only three forb species (Otto and others, 2017). Social science publications have highlighted that initial cost of implementation can be a perceived drawback/barrier for farmers considering the incorporation of prairie strips on their lands (Becker and others, 2019). Understanding which forbs are (1) preferred by bees, (2) able to establish well, and (3) less expensive will help land managers make cost-effective decisions. Furthermore, common physical characteristics or functional traits of forbs that are preferred by bees can potentially be uncovered. A functional trait is defined as any morphological, physiological, or

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phenological trait that affects a plant's fitness indirectly via the trait's effects on performance (Violle and others, 2007). Rowe and others (2020) measured functional traits such as floral area, flower height, and week of peak bloom to determine how these traits were related to visitations of bees. They determined that floral area was a functional trait that was positively correlated with visitation frequencies of certain bee groups, such as bumble bees and other wild bees (Rowe and others, 2020). Other studies have examined how characteristics such as a plant's indigenous status, plant family, flower color, flower morphology, and inflorescence type affected bee visitation (Robson, 2014; Roof and others, 2018). Having a greater understanding of and access to information on forbs that are preferred by bees and are cost effective, along with their common physical characteristics, could potentially increase adoption of pollinator habitat.

The purpose of this report is to combine results of two previously published manuscripts on bee-flower preferences and forb establishment success with a new synthesis of forb physical characteristics and functional traits to identify forbs that provide maximum benefit in conservation plantings in the Prairie Pothole Region, USA. Forbs preferred and (or) highly visited by honey bees and wild bees are listed in Simanonok and others (2021), and information on forb cost-effectiveness and apparent establishment success is detailed in Simanonok and others (2022). A thorough literature review on the physical characteristics and functional traits of forbs preferred and (or) highly visited by honey bees and wild bees, identified through our previous studies, was completed. Results of this research can be used to understand the common characteristics of cost-effective forbs in pollinator habitat plantings.

Methods

Information presented in Simanonok and others (2021) was used to first compile a list of forbs that were preferred and (or) highly visited by honey bees or wild bees. For this study, bees and forbs were surveyed from June through September 2015–19 in Minnesota, North Dakota, and South Dakota. The study included a total of 244 sites in different grassland cover types: private lands enrolled in Federal programs (that is, Conservation Reserve Program, Conservation Stewardship Program, Environmental Quality Incentives Program, Grassland Reserve Program, or Wetlands Reserve Program), roadsides, privately owned pastures and grasslands, State or Federal lands, and private lands enrolled in the Bee & Butterfly Habitat Fund (<https://www.beeandbutterflyfund.org/>). At each site, several 20- by 2-meter transects were surveyed by technicians. Transects were surveyed three times each year representing three bloom periods—early surveying was from June 8 to July 15, middle surveying was from July 16 to August 15, and late surveying was from August 16 to September 28. Technicians counted the number of flowering stems and the number of honey bees or wild bees visiting

flowers within each transect. After completing counts of flowers and bees, technicians spent 5 minutes netting and capturing wild bees that were observed contacting the reproductive parts of a flower. Data generated during this study are available as a U.S. Geological Survey data release (Otto and others, 2020a).

Selection ratios were calculated from the dataset for each forb visited by bees. For the plant-bee data, the selection ratio was calculated by comparing proportions of usage (number of bee visits) and availability (number of flowering stems). The selection ratio describes whether a forb was preferred, avoided, or used neutrally by bees. If a forb was preferred, it was visited by bees more than expected based on the forb's availability. We calculated results separately by bloom period and bee group (honey bees and wild bees). We also described highly visited forb species, defined as those with the greatest proportion of use within each bloom period. For this report, all forb species preferred or highly visited by bees, regardless of the bloom period, are listed.

We obtained the original seed mixes used on certain USDA conservation program sites within our study and then detailed the cost-effectiveness of each forb in our preferred or highly visited list. Sites ranged from 1 to 18 years old (seeding to first year of sampling), and most sites were surveyed at 1–2 years postestablishment. Cost-effectiveness was determined in Simanonok and others (2022) by identifying forbs that (1) were preferred or highly visited by bees, (2) had greater than average apparent establishment rates, and (3) had less than average seed cost. Apparent establishment rate was defined as the proportion of sites in which a seeded forb species was observed blooming during at least 1 bloom period in either of the 2 selected survey years at a site. This rate is called the apparent establishment rate because only blooming forbs were counted and a thorough census of each site was not completed, so some rare forbs could have been missed. Seed cost was determined from a Natural Resources Conservation Service cost spreadsheet used by regional planners and included the number of seeds per pound of a forb and cost per pound averaged across multiple seed vendors (John Englert, Natural Resources Conservation Service, unpub. data, 2021). The average forb establishment rate and average seed cost across all forbs were calculated separately within three groups based on the average seeding rate (low, medium, high). If a forb species had a larger-than-average apparent establishment rate and a smaller-than-average seed cost within each seeding rate group, the forb was considered most cost effective (vice versa for least cost effective). Cost-effectiveness ratings were not available for all listed forb species because not all forbs were seeded in our dataset (for example, volunteer, noxious weeds).

After compiling the list of preferred or highly visited forbs coupled with cost-effectiveness ratings, we filled in information on physical or general characteristics of interest including plant family, indigenous status, life cycle, and flower color using the PLANTS database (Natural Resources Conservation Service, 2021) and Minnesota Wildflowers web page (Minnesota Wildflowers, 2021). Information on wetland

status, drought tolerance, carbon to nitrogen ratio, and nitrogen fixation from each forb's PLANTS database profile also was included when available. An entry of NA was recorded for drought tolerance, carbon to nitrogen ratio, and nitrogen fixation if no information was available. If a species' wetland status was not available for the Great Plains region, the National Wetland Plant List (U.S. Army Corps of Engineers, 2020) was checked. Species' wetland statuses were defined as follows: facultative wetland (usually detected in wetlands but occasionally detected in nonwetlands), facultative (equally likely to be detected in wetlands and nonwetlands), facultative upland (usually detected in nonwetlands but occasionally detected in wetlands), and upland (almost always detected in nonwetlands in the region specified). Species not included on the National Wetland Plant List are considered upland species in all wetland regions where the plant is detected. For a functional trait component, information on bloom period was included by recording the first and last dates each forb was observed blooming during transect surveys (as described previously). Then, the months each forb was observed blooming were graphed and color coded by the average number of flowering stems per transect.

Results of Forb Observations

Overall, 22 forb species were preferred and (or) highly visited by each bee group (table 1). Honey bees preferred 4 forb species, and wild bees preferred 14 total forb species (table 1). Honey bees and wild bees preferred only two of the same forb species—*Cirsium arvense* (L.) Scop. (Canada thistle; a noxious weed) and *Gaillardia aristata* Pursh (blanketflower; a native forb). A total of 9 forbs were highly visited by honey bees, and 14 forbs were highly visited by wild bees (table 1). *Monarda fistulosa* L. (wild bergamot), *Oligoneuron rigidum* (L.) Small (stiff goldenrod), *Phacelia tanacetifolia* Benth. (lacy phacelia), and *Sinapis arvensis* L. (charlock mustard) demonstrated high visitation rates by honey bees and wild bees.

After analyzing a subset of USDA conservation program sites that had known seed mixes, average seeding rates and average apparent establishment rates for 13 of the 22 forb species were determined to characterize cost-effectiveness (table 2). Most forb species preferred and (or) highly visited

by either bee group were considered most cost effective (11 out of 13 forbs). Blanketflower, *Melilotus officinalis* (L.) Lam. (sweetclover), and *Ratibida columnifera* (Nutt.) Wootton & Standl. (upright prairie coneflower) were detected at all sites where they were seeded (100-percent establishment success). Stiff goldenrod was considered least cost effective because of its less than average establishment rate and greater than average seed cost. Several State-listed noxious weeds colonized conservation plantings and were preferred by honey bees or wild bees (tables 1 and 2). We do not have seeding data on three native forbs that were never seeded within our subset of sites (*Cirsium flodmanii* (Rydb.) Arthur [Flodman's thistle], *Grindelia squarrosa* (Pursh) Dunal [curlycup gumweed], and lacy phacelia).

This section describes physical characteristics and functional traits of forb species preferred and (or) highly visited by honey bees or wild bees. Forb species were from a variety of families including Apiaceae, Asteraceae, Brassicaceae, Fabaceae, Hydrophyllaceae, Lamiaceae, and Plantaginaceae. More than 60 percent of forbs were from the family Asteraceae (14 of 22 forbs; fig. 1). Life cycle ranged from annual to biennial to perennial and flower colors ranged widely (table 2). Forb species also represented a range of wetland statuses—1 species was facultative wetland, 5 species were facultative, 6 were facultative upland, and 10 were upland (fig. 2). For forb species with drought tolerance information available, most demonstrated medium or high drought tolerance (table 2). Carbon to nitrogen ratios were listed as low for three, medium for six, and high for one forb species, and the remaining species had no data. Two forb species were medium or high nitrogen fixers—*Medicago sativa* L. (alfalfa) and sweetclover (table 2).

Most species demonstrated a wide bloom period from June to September (fig. 3). Several species, such as *Agastache foeniculum* (Pursh) Kuntze (blue giant hyssop), blanketflower, and *Zizia aurea* (L.) W.D.J. Koch (golden zizia), demonstrated their greatest abundance during the early part of the growing season, whereas *Symphotrichum novae-angliae* (L.) G.L. Nesom (New England aster) was only observed in August and September and would be considered a late-season bloomer. Alfalfa, sweetclover, and lacy phacelia were examples of species that had a large average number of flowering stems per transect throughout all months surveyed.

Table 1. Forb species preferred and (or) highly visited by honey bees or wild bees.

[Results are from surveys completed June through September 2015–19 in Minnesota, North Dakota, and South Dakota. X, denotes yes; —, denotes no]

Common name ^{a, b}	Scientific name ^{a, b}	High honey bee visits	Preferred by honey bees	High wild bee visits	Preferred by wild bees
Alfalfa	<i>Medicago sativa</i> L.	X	—	—	—
Blanketflower	<i>Gaillardia aristata</i> Pursh	—	X	X	X
Blue giant hyssop	<i>Agastache foeniculum</i> (Pursh) Kuntze	X	X	—	—
Bull thistle	<i>Cirsium vulgare</i> (Savi) Ten.	—	—	X	X
Butter and eggs ^c	<i>Linaria vulgaris</i> Mill.	X	—	—	—
Canada thistle ^c	<i>Cirsium arvense</i> (L.) Scop.	X	X	—	X
Charlock mustard	<i>Sinapis arvensis</i> L.	X	—	X	X
Curlycup gumweed	<i>Grindelia squarrosa</i> (Pursh) Dunal	—	—	X	—
Eastern purple coneflower	<i>Echinacea purpurea</i> (L.) Moench	—	—	X	X
Field sowthistle ^c	<i>Sonchus arvensis</i> L.	—	—	—	X
Flodman's thistle	<i>Cirsium flodmanii</i> (Rydb.) Arthur	—	—	X	X
Golden zizia	<i>Zizia aurea</i> (L.) W.D.J. Koch	—	—	X	—
Lacy phacelia	<i>Phacelia tanacetifolia</i> Benth.	X	—	X	—
Maximilian sunflower	<i>Helianthus maximiliani</i> Schrad.	—	—	X	X
New England aster	<i>Symphotrichum novae-angliae</i> (L.) G.L. Nesom	—	—	X	—
Nodding plumeless thistle ^c	<i>Carduus nutans</i> (L.)	—	—	X	X
Pinnate prairie coneflower	<i>Ratibida pinnata</i> (Vent.) Barnhart	—	—	X	X
Smooth oxeye	<i>Heliopsis helianthoides</i> (L.) Sweet	—	—	—	X
Stiff goldenrod	<i>Oligoneuron rigidum</i> (L.) Small	X	—	X	X
Sweetclover	<i>Melilotus officinalis</i> (L.) Lam.	X	X	—	—
Upright prairie coneflower	<i>Ratibida columnifera</i> (Nutt.) Wooton & Standl.	—	—	—	X
Wild bergamot	<i>Monarda fistulosa</i> (L.)	X	—	X	X

^aCommon and scientific names follow the PLANTS database (Natural Resources Conservation Service, 2021).^bSome species listed in this table may be considered weedy—consult with local recommendations before seeding.^cSpecies that are listed as noxious weeds by the Minnesota, North Dakota, or South Dakota State Department of Agriculture.

Table 2. Forb species preferred and (or) highly visited by honey bees or wild bees and their physical or general characteristics.

[C:N, carbon to nitrogen; A-P, annual to perennial; P, perennial; NA, not applicable; B, biennial; A, annual; A-B-P, annual to biennial to perennial; B-P, biennial to perennial]

Common name ^a	Indigenous status ^b	Duration	Flower color	Drought tolerance	C:N ratio	Nitrogen fixation	Cost-effectiveness rating (seeding rate group)
Alfalfa	Introduced	A-P	Purple	High	Low	High	Most (high)
Blanketflower	Native	P	Yellow	Medium	Medium	None	Most (high)
Blue giant hyssop	Native	P	Blue violet	NA	NA	NA	Most (high)
Bull thistle	Introduced	B	Reddish purple	NA	NA	NA	NA
Butter and eggs ^c	Introduced	P	Yellow orange	NA	NA	NA	NA
Canada thistle ^c	Introduced	P	White pink	NA	NA	NA	NA
Charlock mustard	Introduced	A	Yellow	NA	NA	NA	NA
Curlycup gumweed	Native	A-B-P	Yellow	NA	NA	NA	NA
Eastern purple coneflower	Native	P	Purple	Low	Medium	None	Most (high)
Field sowthistle ^c	Introduced	P	Yellow	NA	NA	NA	NA
Flodman's thistle	Native	P	Reddish purple	NA	NA	NA	NA
Golden zizia	Native	P	Yellow	NA	NA	NA	Neutral (medium)
Lacy phacelia	Native	A	Blue	Medium	Medium	None	NA
Maximilian sunflower	Native	P	Yellow	Medium	Low	None	Most (medium)
New England aster	Native	P	Purple	NA	NA	NA	Most (low)
Nodding plumeless thistle ^c	Introduced	B-P	Purple	NA	NA	NA	NA
Pinnate prairie coneflower	Native	P	Yellow	Medium	Medium	None	Most (medium)
Smooth oxeye	Native	P	Yellow	High	Medium	None	Most (high)
Stiff goldenrod	Native	P	Yellow	High	High	None	Least (low)
Sweetclover	Introduced	A-B-P	White/yellow	High	Low	Medium	Most (high)
Upright prairie coneflower	Native	P	Yellow	Medium	Medium	None	Most (low)
Wild bergamot	Native	P	Pink purple	None	NA	None	Most (medium)

^aCommon names follow the PLANTS database (Natural Resources Conservation Service, 2021).^bIndigenous status was determined from PLANTS database as being native to any of the States.^cSpecies that are listed as noxious weeds by the Minnesota, North Dakota, or South Dakota State Department of Agriculture.

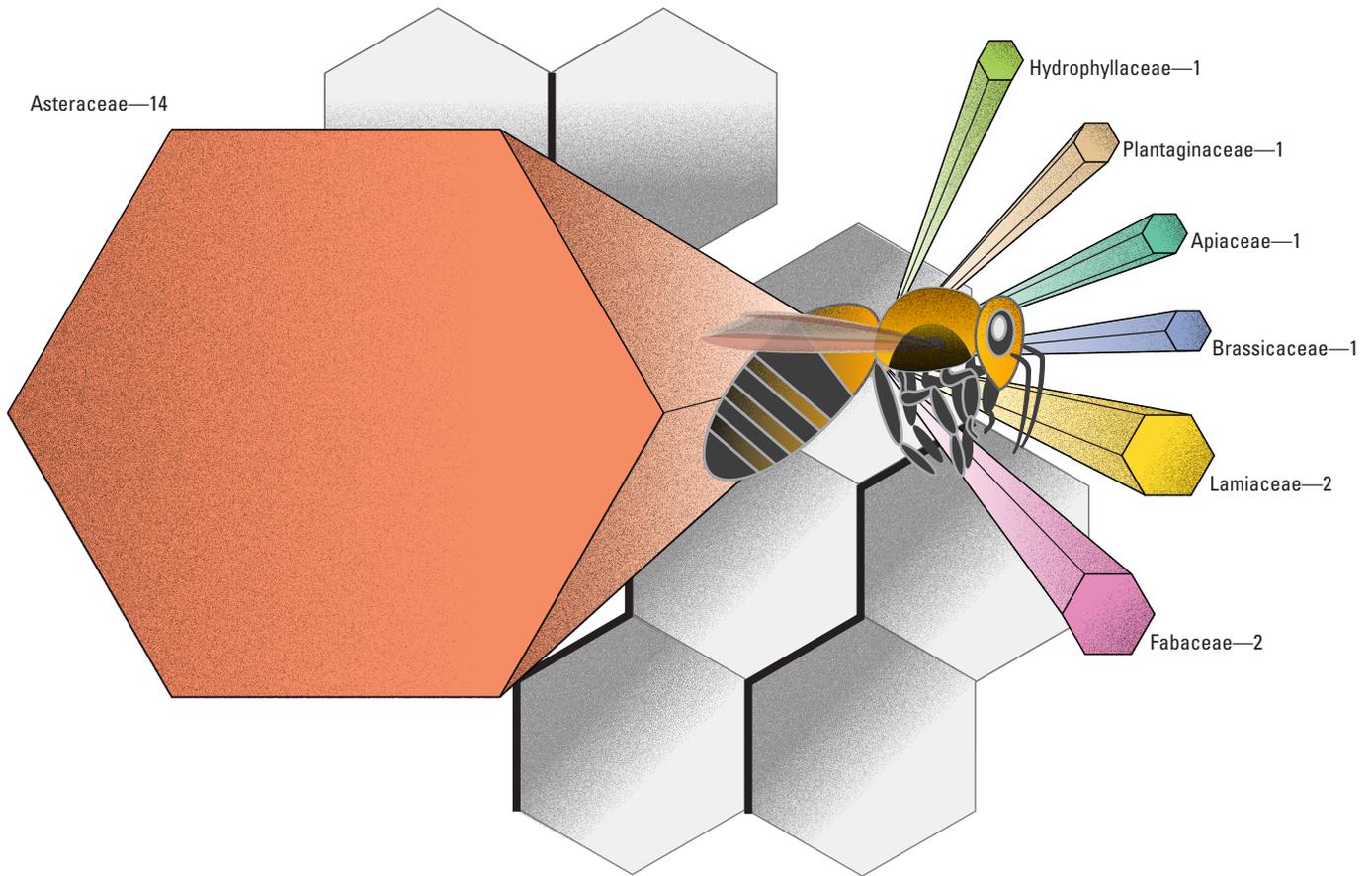


Figure 1. The number of forb species preferred and (or) highly visited by honey bees or wild bees within each plant family (of 22 total forb species).

Conclusion

Of the 22 forb species assessed for cost-effectiveness that were determined to be preferred and (or) highly visited by bees, more than 80 percent were considered most cost effective. Because the cost of a pollinator habitat planting can be a deterrent to some land managers, it is useful to know which species are preferred and (or) highly visited by bees and to know that most of these species are cost effective. Forb species preferred and (or) highly visited by honey bees were often different from forb species preferred and (or) highly visited by wild bees, which indicates that seed mixes may need to be altered depending on the target bee group. For example, blue giant hyssop, alfalfa, and sweetclover were favored by honey bees but not wild bees. On the other hand, *Echinacea purpurea* (L.) Moench (eastern purple coneflower) and Maximilian sunflower were forb species favored by wild bees but not honey bees.

Most forb species were from the Asteraceae family, which corroborates other research on pollinator-friendly forbs. Forb species in the Asteraceae family were determined to be most attractive to wild bees in a study on eastern U.S. native plants (Tuell and others, 2008) and to wild pollinators in the tallgrass prairies of the Northern Plains (Robson, 2014). Preferred and (or) highly visited forb species represented a range of wetland statuses from facultative wetland to upland, indicating that wetland and nonwetland habitat types represent areas where important floral resources for bees exist. This finding is encouraging because the USDA administers multiple programs and practices designed to restore wetlands in working landscapes. Wetland margins in the Prairie Pothole Region serve an important role in supporting native bee abundance and diversity near crop fields (Vickruck and others, 2019). Many USDA Farm Bill conservation programs are tailored to wetland areas and can include pollinator resources (U.S. Department of Agriculture, 2015). Preferred and (or) highly visited forb species with drought information available

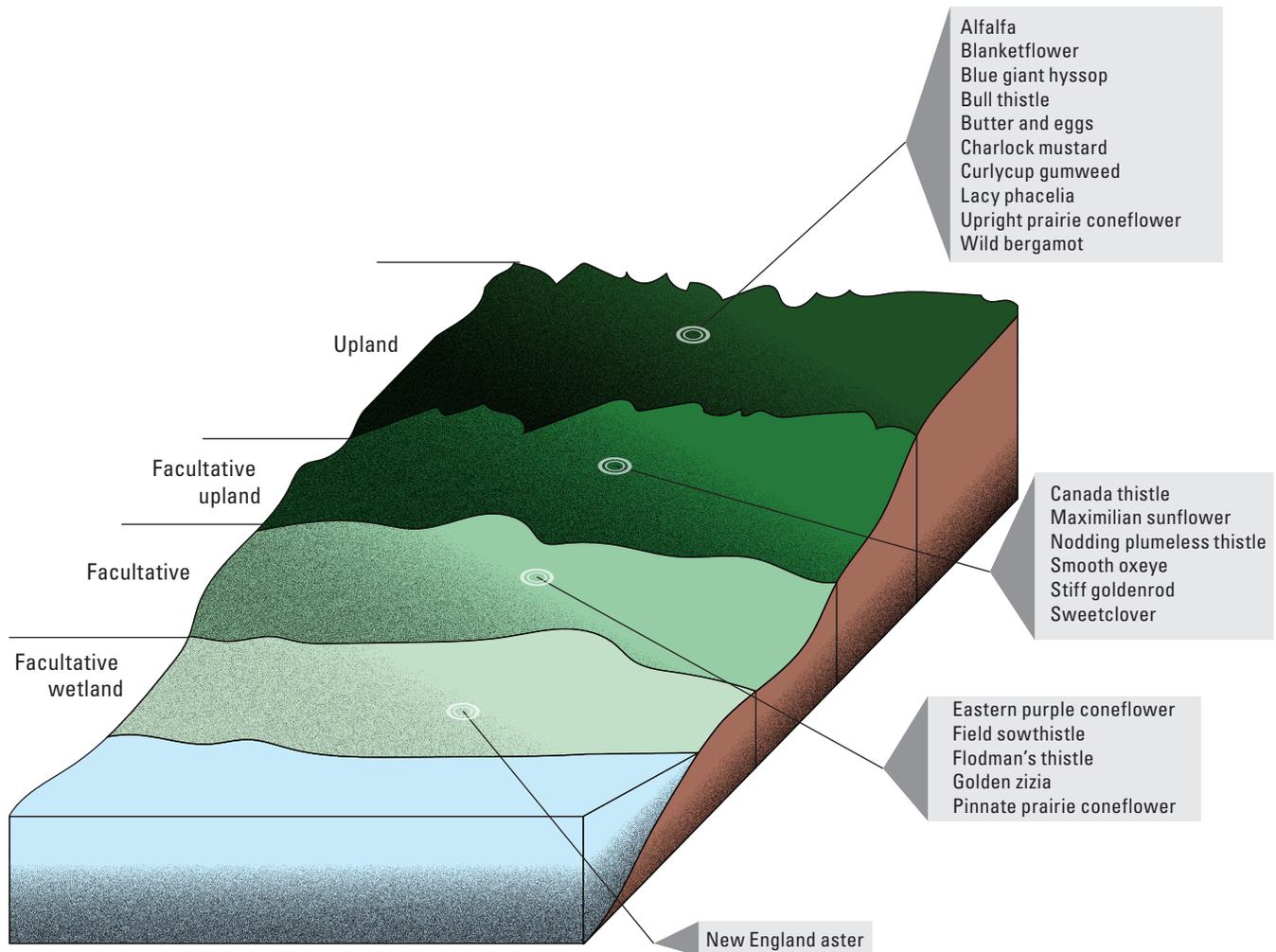


Figure 2. Wetland status of forb species preferred and (or) highly visited by honey bees or wild bees according to the PLANTS database (Natural Resources Conservation Service, 2021) and the National Wetland Plant List (U.S. Army Corps of Engineers, 2020).

demonstrated medium or high drought tolerance, which also is encouraging given the possibility of drought negatively affecting establishment of pollinator habitat plantings.

Most forb species demonstrated a wide range of blooming time from June or July to September; however, previous research has identified the early (June) and late (September) season as potential dearth periods for honey bees, which are time periods when most colonies are losing weight (Otto and others, 2020b). Identifying which early- and late-season bloomers are most cost effective may help the USDA develop pollinator habitat plantings that provide pollen and nectar sources during periods when floral resources are limited for bees. Fortunately, our analysis identified several forbs, such as blue giant hyssop, blanketflower, Maximilian sunflower, and golden zizia, that can provide floral resources during early- and late-season dearth periods.

Other research has examined functional traits of forbs in more detail and determined that plot floral area, flower height, and pollen quantity were important traits affecting wild bee community structure (Rowe and others, 2020). Because certain functional traits were not measured in the field, future studies could assess the relations between forbs preferred by bees and measurable functional traits like floral area and flower height. A newer vein of research is examining how foraging preferences of bees are affected by pollen quality; for example, foraging rates by a commercial bumble bee species increased with plants that had higher protein to lipid ratios (Vaudo and others, 2016).

Many sampled sites would be considered young plantings, growing within the first few years of their USDA contract duration. It is possible the dynamics of cost-effective forbs for pollinator habitat seed mixes may change through time as plantings mature. Establishment of planted species can

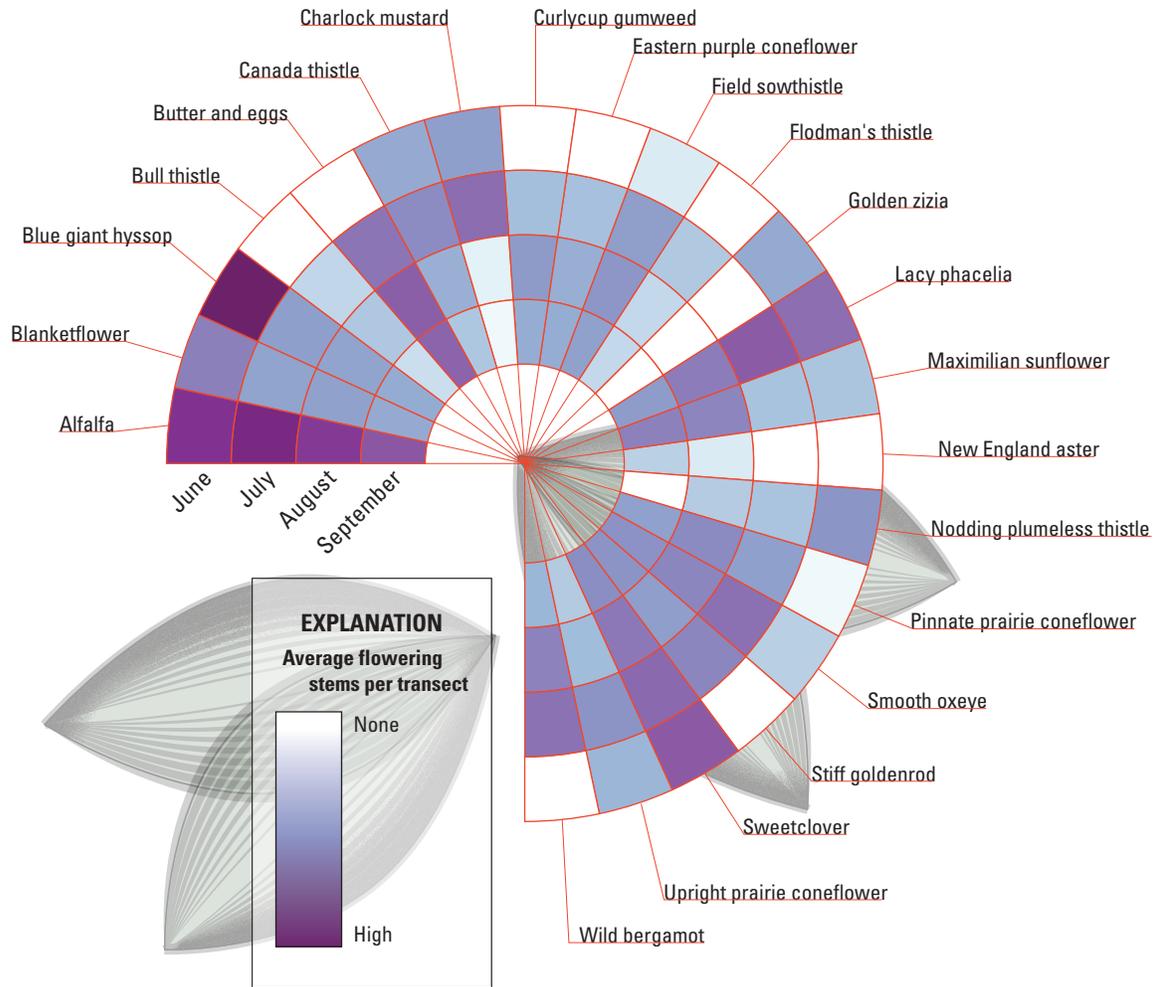


Figure 3. Average flowering stems per transect by observed blooming months for forb species preferred and (or) highly visited by honey bees or wild bees.

fluctuate through time (Wilkerson and others, 2014). Some forb species may not mature to flowering status for at least a couple of years, whereas other species may start strong and then fade as years pass. More research that assesses the cost-effectiveness of pollinator habitat plantings across regions and across years is needed. Future studies may examine high-diversity conservation plantings across longer contract durations to assess establishment and longevity of species planted and pollinator value across USDA Farm Bill programs. Another factor that may affect the cost-effectiveness of pollinator plantings and forb establishment success is postplanting management. Postplanting management includes actions such as mowing, burning, or spot spraying to reduce competition from undesired species. This important factor could affect the number of seeded forbs observed growing at a site and their continued vigor through time because plantings can face invasion by nonseeded species. Although data on postplanting actions were either not available or of insufficient

detail to include in this study, other studies have highlighted the importance of postplanting management on the performance of grassland plantings (Norland and others, 2015; Drobney and others, 2020).

This study provides information on bee-flower preferences, seed cost, and forb establishment rates, thereby contributing to a national effort to increase the cost-effectiveness and biological effect of pollinator habitat restorations. The work in this study can be extended by completing a more thorough assessment of pollinator habitat across a broader range of USDA conservation enrollment age classes and improved understanding of postplanting management effects on forb establishment and retention.

Summary

Establishing and enhancing pollinator habitat to support declining bee populations is a national goal within the United States. Pollinator habitat is often created through incentive-based conservation programs, and the inclusion of cost-effective forbs within the habitat design is a critical component of such programs. U.S. Geological Survey research from 2015 to 2019 identified forb species that (1) were preferred or highly visited by bees, (2) demonstrated high rates of establishment success, and (3) could be purchased at reduced cost. In this report, we enhance this past research by identifying common physical characteristics and functional traits of these cost-effective forbs so that land managers may have easy access to information on cost-effective forbs for new conservation plantings. This report highlights 22 forb species that were preferred and (or) highly visited by honey bees or wild bees. Of the species evaluated for cost-effectiveness, most had less than average seed cost and greater than average apparent establishment rates. Several forb species were not considered cost effective because of bee avoidance, poor establishment, or high seed cost. Forb species preferred and (or) highly visited by honey bees were often different from forb species preferred and (or) highly visited by wild bees, which indicates that seed mixes may need to be altered depending on the target bee group. Most forbs preferred or highly visited by bees were from the Asteraceae family and demonstrated a wide range of flower color. Forb species represented a range of wetland statuses from facultative wetland to upland, indicating that wetland and nonwetland habitat types represent areas where important floral resources for bees exist. Preferred or highly visited forb species with drought information available demonstrated medium or high drought tolerance, which also is encouraging given the possibility of drought negatively affecting establishment of pollinator habitat plantings. Many forb species were in bloom from June to September, but our results showcase forb species that could be used in conservation projects seeking early- (June–July) or late-season (August–September) floral resources for pollinators. More research that assesses the cost-effectiveness of pollinator habitat plantings across regions and across years is needed. Future studies may examine high-diversity conservation plantings across longer contract durations to assess establishment and longevity of species planted and pollinator value across U.S. Department of Agriculture Farm Bill programs.

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