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Photo credit: Leif Richardson

Enhancing Wild Bees for Crop Pollination:

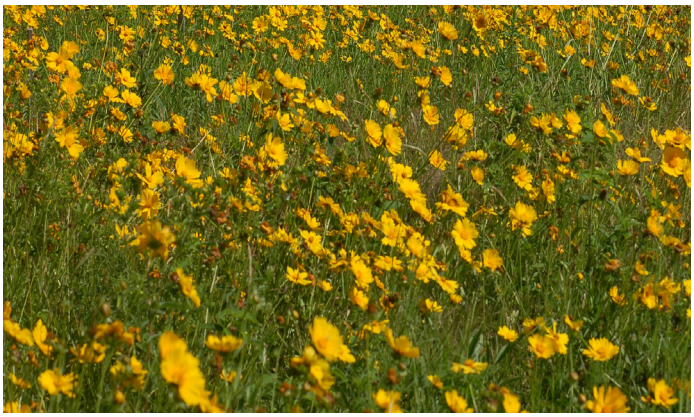
Sowing Bee Pasture for New England's Wild Lowbush Blueberry

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As the cost and supply of honeybee hives becomes more and more unreliable, an increasing number of growers are decreasing reliance on honeybees by managing wild bee populations. One popular method for enhancing wild bee populations is the installation of bee pasture. This publication outlines current best management practices for the planning and installation of wild bee pastures on farms, with special focus on the lowbush blueberry agroecosystem. The techniques and procedures outlined in this fact sheet were researched and tested in 2012 and 2013 in lowbush blueberry fields in Maine.

What is Bee Pasture?

Bee pasture, also called pollinator plantings or bee gardens, are areas of flowering plants managed to provide food for pollinators. Like honeybees, wild bees require pollen and nectar for food. Farmers can provide their wild bee community with food by planting and maintaining areas of flowering plants, thereby increasing their landscapes potential for supporting large populations of pollinators. Healthy populations of wild bees enhance pollination and provide insurance against unstable supplies of managed pollinators.



Early summer bloom of Coreopsis lanceolata in lowbush blueberry bee pasture in Maine. Photo credit, Eric Venturini.

How Does it Work?

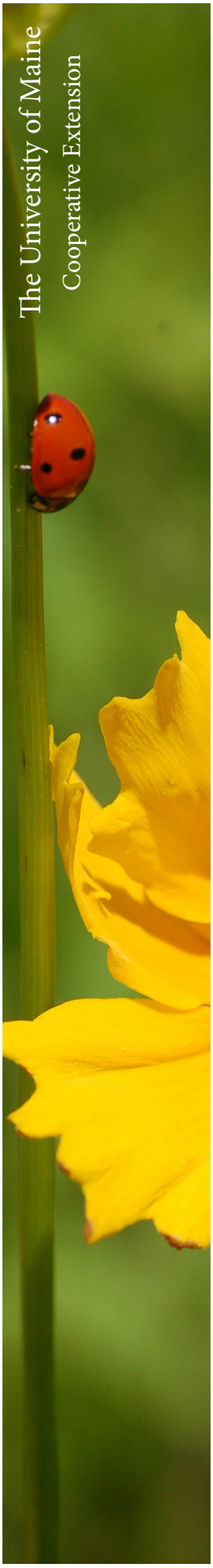
The goal of any bee pasture is to increase the population of wild, unmanaged pollinators by providing them with food. Greater numbers of wild bees decrease reliance on managed pollinators like the honeybee. For bee pasture to enhance wild bees, the growth of the local wild bee population must be limited, or constrained, by their food resources. If wild bees are limited by some other constraint, for example lack of nesting sites and abundance of predators, then increasing their food supply (flowers) is less likely to increase their abundance. As discussed later in this publication, the timing of bloom is also a key component of successful bee pasture.

A Multi-Faceted Approach

We recommend a multi-faceted approach to managing on-farm wild bees. There are many options in addition to bee pasture. Some of these tools are listed below:

- *Decrease pesticide applications, use pesticides with reduced toxicity to bees, and avoid applying multiple classes of pesticides simultaneously.*
- *Install nesting boxes to increase populations of Osmia and mason bees. This increases bee visitation rates to lowbush blueberry flowers .*
- *Maintain areas as non-woody plants and woody shrubs, providing food and nesting resources for many species of wild bees.*

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Step by Step: How to install a successful bee pasture

Site Location

The first step of installing bee pasture is selecting an area to plant. The final decision depends on the situation, but often farmers will choose a site that meets some or all of the following conditions:

- *The area is not good for growing crops. In some fields this may be a shaded southern field edge. In blueberry fields it could be weedy areas with sparse patches of blueberry.*
- *The site is close to the crop field, less than 20 yards is ideal.*
- *Areas of coniferous forest adjacent to the crop field. If equipment for clearing is available this can be an excellent option.*

Site Preparation

Weed Control

One of the biggest challenges of installing bee pasture is weed pressure. Uncontrolled weeds cause bee pasture to fail to establish, establish poorly, or fail to persist. Adequate weed control takes time, and should be the first priority for successful wildflower establishment. A number of different weed control strategies can help habitat managers deplete their weed population as quickly as possible.



Above: *Farmer flame-weeding for weed control. Photo courtesy of E. Gallandt.* ***Below:*** *Eric Venturini and Audrey Maddox removing debris from the seedbed. Photo courtesy of F. Drummond.*

While tempting, spraying a single herbicide application prior to sowing a wildflower mix only temporarily relieves weed pressure without controlling the weed seedbank. If large numbers of weed seeds remain in the soil they will germinate and outcompete the perennial wildflowers.

For organic farmers, one of the most effective tools for weed control is stale seed bedding. Stale seed bedding is the act of shallowly tilling the seed bed every 1-2 weeks. The longer this is performed, the fewer weed seeds remain. Stale seed bedding works by depleting the number of weed seeds present in the soil.

Conventional farmers can use a similar strategy, but instead of tilling, use a broad-spectrum herbicide. Where large aggregations of soil nesting bees occupy the site, herbicides can do less harm than tillage. By allowing weeds to germinate between herbicide applications, conventional farmers can quickly deplete numbers of weed seeds in the top soil layer. If the soil is tilled after herbicide applications and before planting seed, however, a flush of weeds may impede successful wildflower establishment. In some cases, hydroseeding may also be a viable alternative.

Soil Preparation

pH

Most flowers commonly included in bee pastures prefer pH between 5.5 and 7. If soil test results show pH below 5.5, follow liming recommendations provided by a soil testing laboratory to raise pH levels to 6 or 6.5. Lime application does not immediately raise pH, but acts over several years. If pH is below 5 during the initial site survey, the site should be limed immediately and a second soil test taken before seeds are sown. If pH is too low at the time of planting, the chances of successful establishment will be reduced.

Macronutrients (NPK)

Native wildflowers require very little soil fertility. Although additional fertilizer can increase wildflower growth, it is much more likely to increase weed growth, resulting in a reduced bee pasture life span or even establishment failure. We do not recommend the use of fertilizers for wildflower plantings.

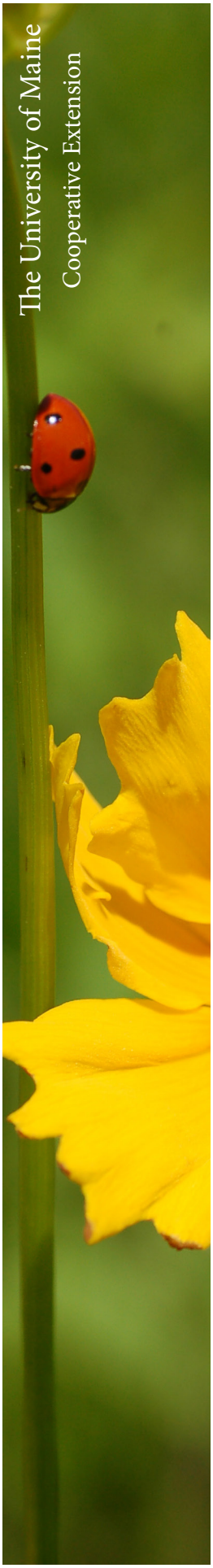


Figure 1: Bloom Phenology of Selected Bee Plants

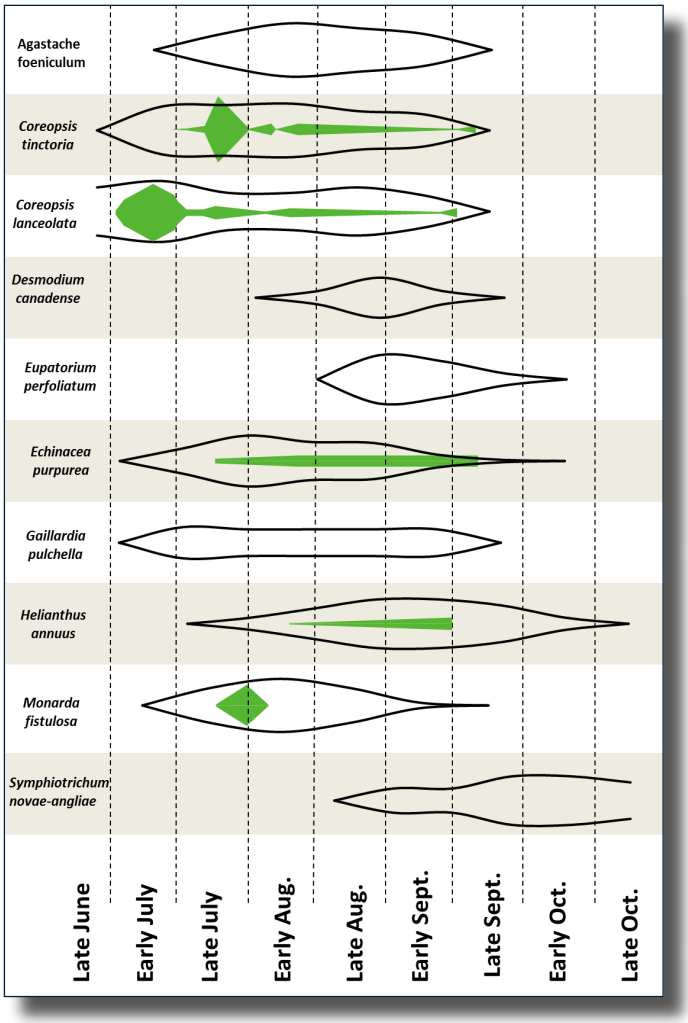
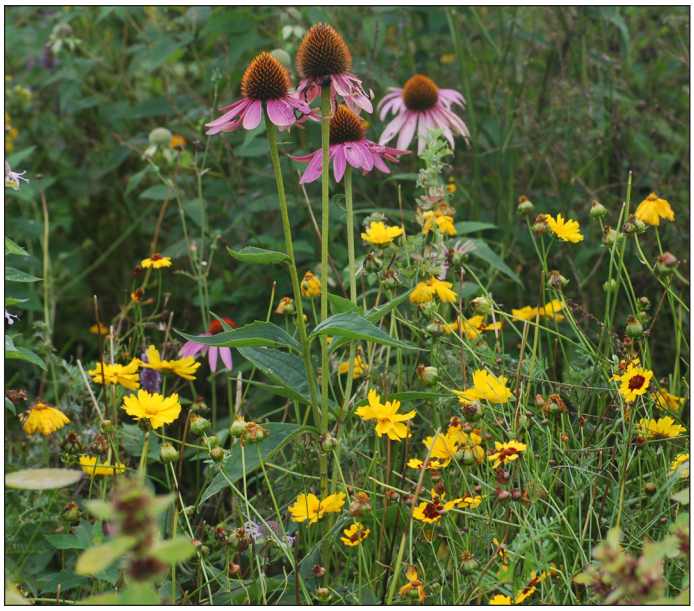


Figure 1: *Graphic depicting the bloom windows (phenology) of a number of attractive bee plants. Green illustrates our own research based flower density measurements and the black outline is based on presence/absence scores. Site specific phenology often occupies a narrower window than generalizations advertised in a seed catalogue.*



Seedbed

Because of their small seeds, most perennial wildflowers require lots of seed to soil contact to germinate. Large seeds also need excellent seed/soil contact. Seed to soil contact is maximized by smooth, well-prepared seedbeds without large soil aggregates, rocks, stumps, or other debris. During initial tillage operations, it is important to remove debris so that a fine soil structure is possible and germination is maximized.

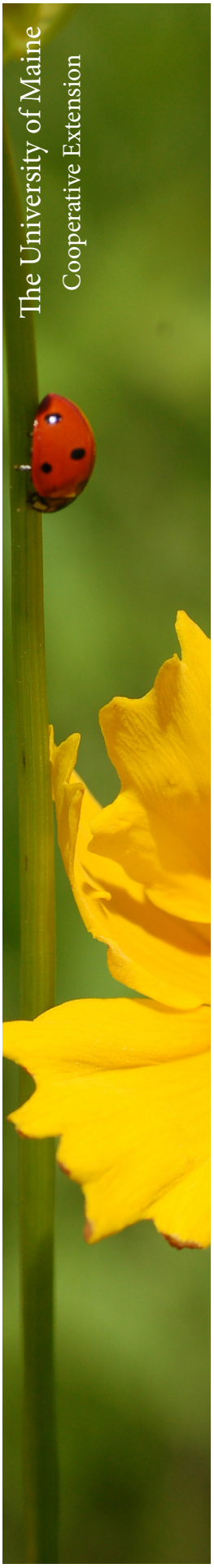
Surveying the Landscape

During the planning phase, we recommend surveying your landscape every few weeks to understand your site's seasonal fluctuations of bloom (phenology). Start in the early spring when willows are one of the only food sources available and continue until mid-late October when New England aster finally succumbs to a hard frost. During these surveys, observe or record the numbers and types of blooming flowers used by wild bees. With this information, you can identify seasonal times of flower scarcity and more importantly, develop a mix of wildflowers that fill these seasonal shortages with abundant sources of pollen and nectar.

Flower Selection: Considerations

Flower and Nectar Content

Flowers for bee pasture should contain an abundance of pollen and nectar. Not all flowers contain both, and some provide more than others. For example common hawkweed (*Hieracium lachenalii*) produces copious amounts of pollen and is highly attractive to bumblebees, yet produces no nectar. Wild bees require pollen for larval provisioning, but also nectar as an adult food source, so if hawkweed is used in bee pasture, a co-flowering nectar source should also be included.



Attractiveness

The attractiveness of bee plants depends on a number of factors that are highly dynamic. For example, what else is flowering nearby? What type of pollinator is the most adept at accessing the flowers pollen and nectar? A number of publications list plants most attractive to bees. Try to use lists that are developed for your region.

Phenology

As a rule, flower mixes should be designed so that during any given part of the season, multiple flowers are in bloom. Ideally, co-flowering plants should attract different pollinator guilds so that all types of wild bees have access to both pollen and nectar at all parts of the season. The graphic on the previous page depicts a number of attractive bee plants and their bloom phenology. This is a good way to conceptualize the phenology of a planned wildflower mix and to identify possible gaps in bloom.

The timing of crop bloom is also important. Providing additional food for bees during parts of the season where food is abundant (during crop bloom) is less beneficial to bees. Secondly, flowers that co-flower with the crop can compete with the crop for bee visits, decreasing crop pollination and potentially clogging crop stigmas with incompatible wildflower pollen.

Weediness

Some of the best bee pasture flower candidates also have potential to become weeds in the crop field. In many cropping systems, this can quickly decrease flower choices. Examples of plants both highly attractive to bees and weedy in blueberry fields include, goldenrods, raspberries, blackberries, bigleaf lupin, apple, maple, black chokeberry, and milkweed. Farmers may want to consider locating potentially weedy bee pasture behind a buffer of trees or on the downwind side of the crop field. A strategy for acid loving crops is to plant only those wildflowers that tolerate relatively pH neutral soils, greatly decreasing any chance that they may become established in the crop field. Another strategy, although time-consuming, it deadheading flowers before they drop seed.

Table 1: Seeding Equipment

	Size of Planting	Cost	Comments
Hand Broadcast	<100 ft²	No cost	Uneven distribution can waste valuable wildflower seed.
Hand Crank Seeder	<1 acre	$30 - $150	Easy to use, inexpensive, and available in a number of sizes.
ATV/Lawn Tractor Pulled Seeder	1 - 10 acres	$200 - $750	Very practical, if already owned.
Native Seed Drill	>1 acre	Prohibitive, rent or borrow	May be available from NRCS or independent contractors.
Hydro Seeder	Any size	Prohibitive, rent or borrow	May be available from NRCS or independent contractors.

Table 1: *Applicability of various types of equipment for sowing wildflower seeds.*

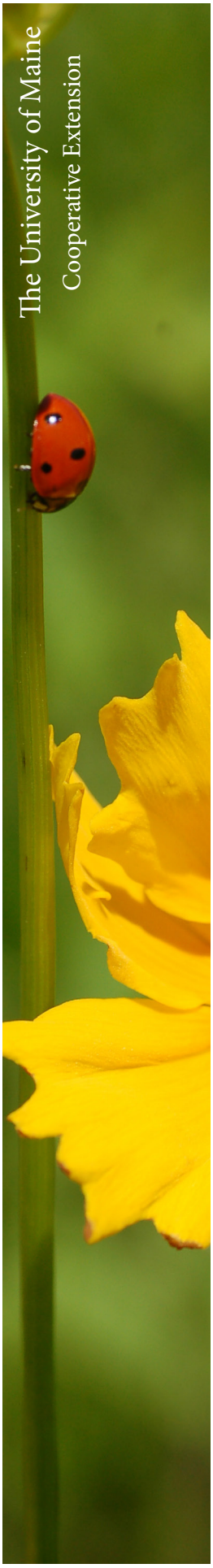


Above: *Compacting the soil with a tractor-pulled weighted roller. Photo courtesy of Audrey Maddox.*

Planting

Weed Control

Unlike the initial seedbed preparations, the operations immediately prior to planting, including planting itself, should minimize soil disturbance. This decreases the number of weed seeds that are moved in the soil and decreases



the final flush of some weed seeds. Some strategies that decrease soil disturbance during seeding include

- *Kill the final flush of weeds by flaming instead of tilling.*
- *Kill the final flush of weeds by spraying with an herbicide instead of tilling.*
- *Conduct final seedbed preparations at night. Even a brief exposure to light during tillage can trigger weed seeds to germinate.*

Sowing Seed

Due to the small size and expense of wildflower seeds, seed should be bulked with sand or fine to medium grade vermiculite before sowing. The ratio for bulking agent to seed should be between 4:1 and 10:1. The exact rate you choose should depend on the seeding equipment used. Seeding equipment with fine scale adjustments for small seeds will require less bulking agent and visa versa. We recommend testing the seed spreader with bulking agent alone until an acceptable speed and application rate is found. See Table 1 above to determine the most appropriate seeding equipment for your site.

Compacting the Soil

To ensure sufficient seed to soil contact, the seed bed must be compacted after sowing. Many bee pastures fail because this step gets skipped. Weighted hand-pulled lawn rollers, tractor- or

"… the seed bed must be compacted after sowing. Many bee pastures fail because this step gets skipped."

ATV-pulled rollers, and culti-packers are all viable options. If the soil is sufficiently compacted, a full-grown person should be able to walk onto the seedbed and leave boot prints that are less than 1/2 inch deep.

Both hydroseeders and native seed drills are typically used on untilled, hard soil surfaces; these seeding methods require no further soil compaction.

Conduct compaction operations when the soil is dry and thoroughly water the seed bed afterward. A good soaking increases germination.

Maintenance

Year 1

During the first several months of the growing season after seed sowing, maintaining a moist seed bed increases germination and establishment. Recommendations vary, but range from ¼ - 1 inch of water per week. In sandy soils or those that lack organic matter, more water may be required. Similarly, in soils with high organic matter content, additional watering may not be necessary.

It is important to keep weeds in check during the first growing season. In small plots hand weeding is possible; but as bee pastures increase in size, hand weeding quickly becomes cost- and time-prohibitive. Some wildflowers can withstand certain herbicides, but care should be taken to avoid exposing bees to herbicide sprays and residues. This extensive topic is covered in detail elsewhere.

Mowing or line-trimming weeds that grow taller than the wildflower seedlings can kill some weeds and prevent others from setting seed. If annual plants are included in the seed mix, then mowing or line-trimming is less effective. The annuals will grow much faster than the perennial wildflowers and can make the difference in height between weeds and wildflowers non-existent, rendering this method ineffective.

Annually

We recommend mowing once each year in the late fall after the wildflowers have stopped blooming to maximize benefits to pollinators and allow wildflowers to set seed. Although mowing is unlikely to impact ground nesting bees, habitat managers might consider scheduling fall mowing after the first hard frost to minimize any potential impacts.

Bee Pasture Economics

Is the investment required to install and maintain bee pasture worth it to the farmer? This is a complicated question and is, as of yet, not completely answered. The worth of bee pasture to farmers is a function of two things: the cost of installation and maintenance, and the value of any resulting increase in pollination services. Although we understand how much bee pasture

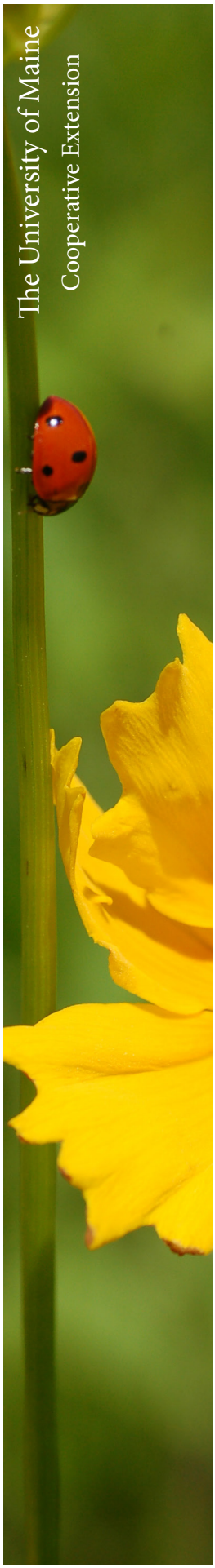


Figure 2: How Much Would a Bee Pasture Have to be Worth to Break Even with its Costs?

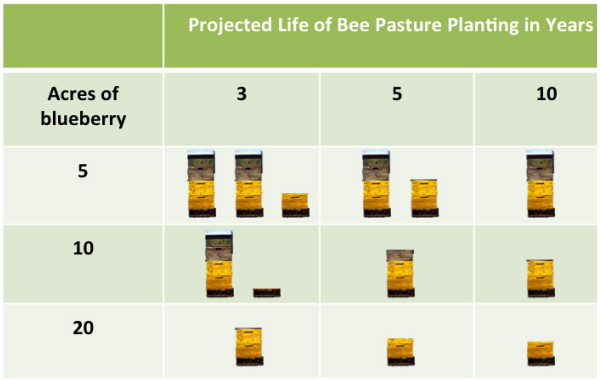


Figure 2: *The amount that an acre of bee pasture would have to be worth to pay for itself (in terms of increased pollination provided by wild bees) expressed as the number of rented honeybee hives/acre of blueberry field. Costs of bee pasture planting are annual total costs per acre under different assumed bee pasture stand lives (3, 5, and 10 years) and ratios of lowbush blueberries acres to bee pasture acres (5:1, 10:1, and 20:1).*

costs, we are still uncertain about how much benefit it provides. So, instead of asking how much value is derived from an enhanced bee community, we have asked a different question: At current market prices, how many hives of managed bees does a bee pasture need to replace in order to pay for itself? See Figure 2 above for the answer to this question.

Cost Share Opportunities

A number of governmental incentive programs can help farmers pay for the cost of installing bee pasture. They are listed below.

Natural Resource Conservation Service - *Environmental Quality Incentives Program (EQIP):*
www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

Farm Service Agency - *Conservation Reserve Program:*
http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp

US Fish & Wildlife Service - *Partners Program:*
http://www.fws.gov/mainefieldoffice/Partners_for_fish_and_wildlife.html

Conclusion

By taking the proper steps prior to ordering seed and converting land to bee pasture, farmers and habitat managers are more likely to create a long-lived and successful bee pasture planting. In summary, we have outlined six key steps to install successful bee pastures.

1. Survey the Site:

Observe and record the site-specific phenology of flowering plants and pollinators.

2. Control Weeds:

First kill the standing vegetation. Then employ methods like stale-seed bedding to decrease the number of weed seeds in the soil.

3. Prepare the Soil:

Use soil testing services to obtain a reading of the soil pH and lime as needed.

4. Select Flowers:

Consider when they bloom, who they attract, ease of establishment, and weediness.

5. Sow Wildflower Seeds:

Prior to seeding, work the soil to ensure a fine seedbed so that the small seeded wildflowers have adequate seed to soil contact for maximum germination rates. Use a bulking agent during seeding to evenly spread seeds. After seeding, thoroughly compact soil and consider watering to maximize germination and establishment.

6. Maintenance:

Mow the bee pasture once each fall after the wildflowers have ceased flowering and set seeds.

Seed Sources

Applewood Seed Company:
www.applewoodseed.com

Johnnys Selected Seeds:
www.Johnnyseeds.com



Additional Reading:

University of Maine Coooperative Extension:

Bulletin #7153, Understanding Native Bees, the Great Pollinators: Enhancing Their Habitat in Maine - http://umaine.edu/publications/7153e/.

Fact Sheet No. 630, Wild Bee Conservation for Wild Blueberry Fields - http://umaine.edu/blueberries/factsheets/bees/630-wild-bee-conservation-for-wild-blueberry-fields/.

Fact Sheet No. 301, Field Conservation Management of Native Leafcutting and Mason Osmia Bees - http://umaine.edu/blueberries/factsheets/bees/301-field-conservation-management-of-native-leafcutting-and-mason-osmia-bees/.

TB191: Conservation and Management of Native Bees in Cranberry - http://digitalcommons.library.umaine.edu/aes_techbulletin/17/.

Mehalled, F. & Schonbeck, M. 2013. Manage the Weed Seed Bank - Minimize "Deposits" and Maximize "Withdrawals." www.extension.org.

The Xerces Society for Invertebrate Conservation:

Attracting Native Pollinators: Protecting North America's Bees and Butterflies, Published by the Xerces Society for Invertebrate Conservation.

Managing Alternative Pollinators: A Handbook for Beekeepers, Growers, and Conservationists, Published by the Sustainable Agriculture Research and Education Program.

Acknowledgements: *We would like to thank the United States Department of Agriculture and the University of Maine for providing funding. Also, Applewood Seed Company generously provided seed and project advice. Julia McGuire provided valuable edits. Last but not least, Jeff Norment of the Maine NRCS informed us of the governmental incentive programs that allow many growers to implement pollinator plantings.*

Table 2: Selected Bee Plants for Lowbush Bluberry

Basic Information

Key:

T = Tree
S/T = Shrub/Tree
HA = Herbaceous annual
BH = Biennial herb
S = Shrub
PH = Perennial herb

*Plants marked as deer resistant are less likely to be browsed by deer.

	Common Name	Scientific Name	Pollen Source	Nectar Source	Pollinators and Beneficials: Bumble Bees	Mining bees	Sweat Bees	Cellaphane Bees	Mason & Orchard Bees	Cuckoo Bees	Honey Bees	Natural Enemies	Habitat & Duration	Deer Resistant?*	Native**
Trees	**Maple**	*Acer* spp. (*saccharinum and rubrum*)	Y	Y	✓	✓	✓	✓	✓				T	No	Yes
	Willow	*Salix* spp. (ie: *bebbiana*)	Y	Y	✓	✓	✓		✓				T	No	Yes
	Shadbush	*Amelanchier* spp. (i.e: *nantucketensis*)	Y	Y	✓				✓				S/T	No	Yes
	Apple	*Malus* spp. (ie: *domesticus)*	Y	Y	✓	✓	✓	✓	✓		✓		S/T	No	No
	Cherry	*Prunus* spp. (ie: *serotina*)	Y	Y	✓	✓	✓	✓			✓	✓	S/T	No	Yes
	Basswood	*Tilia americana*	Y	Y	✓	✓	✓						T	No	Yes
Crops	**Lowbush Blueberry**	*Vaccinium angustifolium*	Y	Y	✓	✓	✓	✓	✓	✓			S	No	Yes
	Blackberry and Raspberry	*Rubus* spp.	Y	Y	✓	✓	✓		✓	✓	✓		S	No	Yes
	Mustards	*Brassica* spp.	Y	Y	✓		✓				✓	✓	HA	No	No
Bee Pasture	**Golden Alexanders**	*Zizea aurea*	Y	Y			✓	✓				✓	PH	Yes	Yes
	Perennial Lupine	*Lupinus perennis*	Y	N	✓				✓				PH	Yes	Yes
	Sweet Yellow Clover	*Melilotus officinalis*	Y	Y	✓		✓			✓	✓	✓	BH	No	No
	Red Clover	*Trifolium pratense*	Y	Y	✓						✓		BH	No	No
	Cow Vetch	*Vicia cracca*	Y	Y	✓		✓				✓		PH	No	No
	Northern Bush Honeysuckle	*Diervilla lonicera*	Y	Y	✓								S	No	Yes
	Purple Coneflower	*Echinacea purpurea*	Y	Y	✓		✓						PH	Yes	No
	Early Goldenrod	*Solidago juncea*	Y	Y	✓	✓	✓	✓	✓	✓		✓	PH	No	Yes
	Lance-Leaved Coreopsis	*Coreopsis lanceolata*	Y	Y	✓	✓	✓		✓			✓	PH	Yes	Yes
	Bergamot	*Monarda fistulosa*	Y	Y	✓		✓					✓	PH	Yes	Yes
	Meadowsweet	*Spiraea alba* var. *latifolia*	Y	Y	✓		✓	✓		✓	✓	✓	S	Yes	Yes
	Milkweed	*Asclepias* spÐ. (ie: *syriaca*)	Y	Y	✓	✓	✓	✓			✓	✓	PH	Yes	Yes
	Plains Coreopsis	*Coreopsis tinctoria*	Y	Y	✓	✓	✓					✓	AH	Yes	No
	Lavender Hyssop	*Agastache foeniculum*	N	Y	✓								PH	Yes	Yes
	Showy Goldenrod	*Solidago speciosa*	Y	Y	✓		✓						PH	No	Yes
	Joe-Pye Weed	*Eutrochium purpureum*	Y	Y	✓		✓	✓					PH	Yes	Yes
	Wild Sunflower	*Helianthus annuus*	Y	Y	✓								AH	Yes	Yes
	Canada Goldenrod	*Solidago canadensis*	Y	Y	✓		✓				✓		PH	No	Yes
	New England Aster	*Symphyotrichum novae -angliae*	Y	Y	✓	✓	✓					✓	PH	Yes	Yes

Table 2: *List of some beneficial pollinator plants, the resources they provide, their associated pollinators, and more. The bloom phenology of these plants can be found on the following page.*

Figure 3: Bee Plants for Lowbush Blueberry

Bloom Phenology

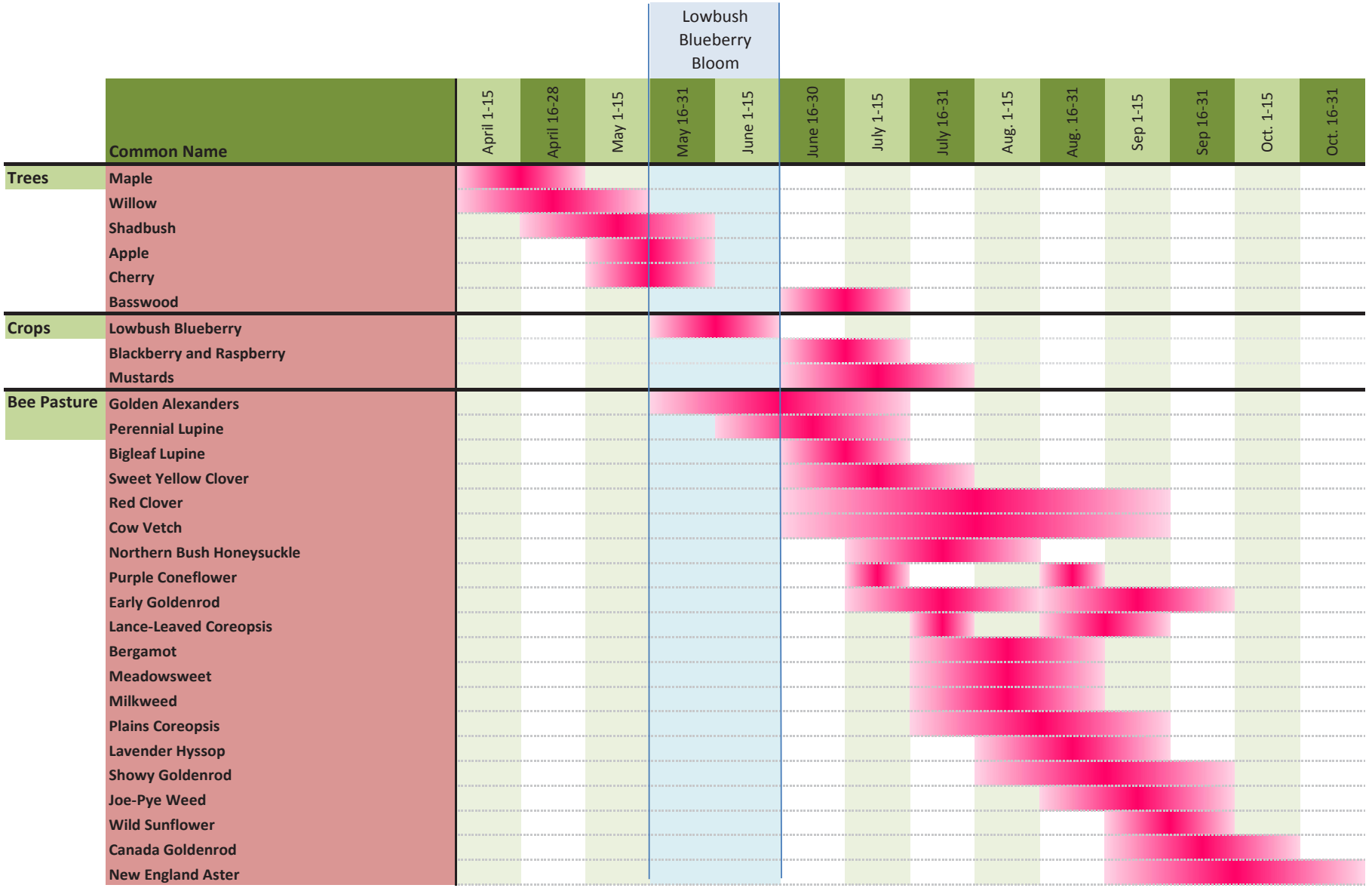


Figure 3: *The phenology, or bloom windows, of a list of recommended bee plants for lowbush blueberry. The area in blue represents the projected bloom of the lowbush blueberry crop. Actual bloom of plants may vary slightly with season and other factors. Additional information about these plants can be found on Table 2 on the previous page.*