POLLINATOR BIOLOGY AND HABITAT

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Natural Resources Conservation Service

New England Biology Technical Note April 2009

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Introduction

This technical note provides information on how to plan for, protect, and create habitat for pollinators in agricultural settings. Pollinators are an integral part of our environment and our agricultural systems; they are important in 35% of global crop production. Animal pollinators include bees, butterflies, moths, wasps, flies, beetles, ants, bats and hummingbirds. This technical note focuses on native bees, the most important pollinators in temperate North America, but also addresses the habitat needs of butterflies and, to a lesser degree, other beneficial insects.

Worldwide, there are an estimated 20,000 species of bees, with approximately 4,000 species native to the United States. The non-native European honey bee (*Apis mellifera*) is the most important crop pollinator in the United States. However, the number of honey bee colonies is in decline because of disease and other factors, making native pollinators even more important to the future of agriculture. Native bees provide free pollination services, and are often specialized for foraging on particular flowers, such as squash, berries, or orchard crops. This specialization results in more efficient pollination and the production of larger and more abundant fruit from certain crops. Native bees contribute an estimated

Sweat bee (*Agapostemon* sp.). Photo: Toby Alexander, Vermont NRCS.

$3 billion worth of crop pollination annually to the U.S. economy.

Undeveloped areas on and close to farms can serve as long-term refugia for native wild pollinators. Protecting, enhancing or providing habitat is the best way to conserve native pollinators and, at the same time, provide pollen and nectar resources that support local honey bees; on farms with sufficient natural habitat, native pollinators can provide all of the pollination for some crops.

Pollinators have two basic habitat needs: a diversity of flowering native or naturalized plants, and egg-laying or nesting sites. The Natural Resources Conservation Service (NRCS) can assist landowners with providing adequate pollinator habitat by, for example, suggesting locally appropriate plants and offering advice on how to provide nesting or egg-laying habitat.

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Pollination Economics in New England

The Northeastern U.S. is a major center for the production of several high-value bee pollinated crops.

The largest of these individual crops, is Maine's 60,000 acres of lowbush wild blueberries (*Vaccinium angustifolium*), which grow naturally in fields and barrens across the central and southern regions of the state. Maine is the largest blueberry producer in the U.S., growing approximately 25 percent of all blueberries in North America and producing an annual crop valued at $75 million.

The perennial crop, which is native to the region, is well adapted to the low fertility and high acid soils of the state and requires few chemical inputs. Maine blueberries are typically produced on a two year cycle with growers harvesting half of their total cropland each year. Following harvest, the plants are aggressively pruned by mowing or burning and then allowed a full year to regenerate before harvest in August.

The majority of Maine's blueberry crop is dependant upon honey bee pollination, typically provided by migratory out-of-state beekeepers who annually transport 50,000 bee hives into the state for the bloom period which lasts from mid-May into June. Researchers at the University of Maine have identified several native bee species that contribute to blueberry pollination, including several species of bumble bees, and the so called "Maine blueberry bee" (*Osmia atriventris),* a tunnel-nesting solitary species.

In addition to Maine, smaller but economically important blueberry industries are found in other New England states. Connecticut for example, is home to the nation's 7th largest blueberry industry. These other state blueberry crops include fresh market and pick-your-own operations, and often produce the larger high-bush blueberries (*Vaccinium corymbosum*).

A close native relative of the blueberry, and the second leading high-value bee pollinated crop in New England is the cranberry (*Vaccinium macrocarpon*). The leading New England cranberry producer is Massachusetts with 14,000 acres of production, on roughly 400 farms. This makes cranberries the number one agricultural commodity in the state. As with blueberries, smaller cranberry industries exist in other Northeastern states including Maine, New Hampshire, Connecticut and even Rhode Island.

Approximately 70 percent of these operations are small family farms consisting of less than 20 acres. In addition to actual production bogs, Massachusetts cranberry growers own and control approximately 48,000 acres of upland and wetland areas that support their operations. Thus for every acre plated in cranberries, three or four acres of surrounding land are needed to support activities like harvest flooding and anti-frost irrigation systems. These surrounding wetlands and upland areas provide wildlife habitat and allow for groundwater recharging.

The Maine blueberry bee (*Osmia atriventris*). Photo: Connie Stubbs, University of Maine.

Much of the cranberry pollination in the Northeast is performed by migratory honey beekeepers moving south in June after the blueberry bloom in Maine. Typical stocking recommendations call for two honey bee hives (each containing 20,000 to 80,000 bees) per acre, with some growers substituting or supplementing honey bees with commercially reared bumble bees. Because of the cranberry flower's morphology, honey bees are considered inefficient pollinators for the crop; however the ability to rapidly supply them in large numbers ensures pollination where native bees are absent or not abundant.

Bumble bees, including *Bombus impatiens, B. bimaculatus*, and *B. vagans*, are considered apex pollinators of cranberry, out-performing honey bees by several times on a bee-for-bee basis. Other native bee specialists of cranberry include the ground-nesting leafcutter bee *Megachile addenda*, and several species of ground nesting bees in the genus *Lassioglossum*.

Tricolored bumble bee (*Bombus ternarius*), visiting an apple blossom in New England. Photo: Connie Stubbs, University of Maine.

Other economically important bee-pollinated crops in New England include tree fruits notably apples (as well as pears and cherries), and various vegetable crops, especially squash and pumpkin. The respective ranking of U.S. apple production for 2004 includes Maine at number 15 (1.1 million bushels annually), Massachusetts at number 16 (1 million bushels), Vermont at 19 (0.9 million bushels), New Hampshire at 22 (0.7 million bushels), Connecticut at 26 (0.5 million bushels), and Rhode Island at 34 (0.1 million bushels).

In New Hampshire alone, there are nearly 100 orchards, and 6,000 acres of fruit and vegetable cropland producing an annual output valued at $18 million. Similarly, Vermont has nearly 4,000 acres of commercial apple production and an annual crop valued at $10-12 million. Connecticut is the 10th largest producer of pears in the U.S. as measured both in terms of acreage and annual yield.

Native Bee Diversity in New England

Based on current data available from nationally recognized bee taxonomists at the American Museum of Natural History, 401 confirmed bee species are found in the states represented by this document. These bees consist of 40 genera and represent all New World bee families.

This data is compiled from multiple sources, and includes extremely large sample sets. For example, the University of Connecticut has contributed more than 13,000 specimens from Connecticut alone to the American Museum of Natural History's database.

Pollinator Conservation and Farm System Planning

A growing emphasis within the NRCS is to take a whole farm approach to conservation efforts. As projects are being considered, field conservation staff must constantly weigh the potential costs against the benefits of the practices they help implement.

Habitat enhancement for native pollinators on farms, especially with native plants, provides multiple benefits. In addition to supporting pollinators, native plant habitat will attract beneficial insects that predate on crop pests and lessen the need for pesticides on the farm. Pollinator habitat can also provide habitat for other wildlife, serve as windbreaks, help stabilize the soil, and improve water quality.

This document provides a four-step approach to pollinator conservation: (1) advice on recognizing existing pollinator habitat, (2) steps to protect pollinators and existing habitat, (3) methods to further enhance or restore habitat for pollinators, and then (4) methods for managing habitat for the benefit of a diverse pollinator community.

Table 1. General native pollinator habitat requirements

Pollinator	Food	Shelter
Solitary bees	Nectar and pollen	Most nest in bare or partially vegetated, well-drained soil; many others nest in narrow tunnels in dead standing trees, or excavate nests within the pith of stems and twigs; some construct domed nests of mud, plant resins, saps, or gums on the surface of rocks or trees
Bumble bees	Nectar and pollen	Most nest in small cavities (approx. softball size), often underground in abandoned rodent nests or under clumps of grass, but can be in hollow trees, bird nests, or walls
Butterflies and Moths – Egg	Non-feeding stage	Usually on or near larval host plant
Butterflies and Moths – Caterpillar	Leaves of larval host plants	Larval host plants
Butterflies and Moths - Pupa	Non-feeding stage	Protected site such as a bush, tall grass, a pile of leaves or sticks or, in the case of some moths, underground
Butterflies and Moths – Adult	Nectar; some males obtain nutrients, minerals, and salt from rotting fruit, tree sap, animal dung and urine, carrion, clay deposits, and mud puddles	Protected site such as a tree, bush, tall grass, or a pile of leaves, sticks or rocks
Hummingbirds	Nectar, insects, tree sap, spiders, caterpillars, aphids, insect eggs, and willow catkins Typically need red, deep-throated flowers, such as cardinal flower, or penstemons	Trees, shrubs, and vines.

[Adapted from: Native Pollinators. Feb. 2006. Fish and Wildlife Habitat Management Leaflet. No. 34.

Natural areas with abundant native forbs that flower when the main crop is not in bloom, such as the goldenrod adjacent to this apple orchard can support resident pollinator populations. Photo: Toby Alexander, Vermont NRCS.

I. Recognizing Existing Pollinator Habitat

Many growers may already have an abundance of habitat for native pollinators on or near their land; having semi-natural or natural habitat available significantly increases pollinator populations. Linear habitats along field margins such as field edges, hedgerows, and drainage ditches offer both nesting and foraging sites. Woodlots, conservation areas, utility easements, farm roads, and other untilled areas may also contain good habitat. Often, marginal areas, less fit for crops, may be best used and managed as pollinator habitat. Here we provide advice on recognizing specific habitat resources so that they can be factored into farm systems planning.

A. Existing Plant Composition

When assessing pollen and nectar resources, it is important to look at all of the potential plant resources on and around a landowner or farmer's property, and which plants are heavily visited by bees and other pollinators. These plants include insect-pollinated crops, as well as the flowers – even "weeds" – in buffer areas, forest edges, hedgerows, roadsides, natural areas, fallowed fields, etc. Insect-pollinated crops may supply abundant forage for short periods of time, and such flowering crops should be factored into an overall farm plan if a grower is interested in supporting wild pollinators. However, for pollinators to be most productive, nectar and pollen resources are needed outside the period of crop bloom.

As long as a plant is not a noxious or state-listed invasive weed species that should be removed or controlled, producers might consider letting some of the native or non-native forbs that are currently present on site to bloom prior to their crop bloom, mow them during crop bloom, then let them bloom again afterward. For example, dandelions, clover, and other non-native plants are often good pollinator plants. Forbs can be mowed during crop bloom; however, one must weight benefits to crop pollination against potential negative effects on ground nesting wildlife. Growers may also allow some salad and cabbage crops to bolt. In addition to pollinators, the predators and parasitoids of pests are attracted to the flowers of arugula, chervil, chicory, mustards and other greens, supporting pest management.

When evaluating existing plant communities on the margins of cropland, a special effort should be made to conserve very early and very late blooming plants. Early flowering plants provide an important food source for bees emerging from hibernation, and late flowering plants help bumble bees build up their energy reserves before entering winter dormancy.

Keep in mind that small bees may only fly a couple hundred yards, while large bees, such as bumble bees, easily forage a mile or more from their nest. Therefore, taken together, a diversity of flowering crops, wild plants on field margins, and plants up to a half mile away on adjacent land can provide the sequentially blooming supply of flowers necessary to support a resident population of pollinators.

B. Nesting and Overwintering Sites

Bees need nest sites. Indeed, to support populations of native bees, protecting or providing nest sites is as important, if not more important, as providing flowers. Similarly, caterpillar hostplants are necessary for strong butterfly populations, if that is a management goal.

The ideal is to have nesting and forage resources in the same habitat patch, but bees are able to adapt to landscapes in which nesting and forage resources are separated. However, it is important that these two key habitat components are not too far apart.

Native bees often nest in inconspicuous locations. For example, many excavate tunnels in bare soil, others occupy tree cavities, and a few even chew out the soft pith of the stems of plants like elderberry or black berry to make nests. It is important to retain as many naturally occurring sites as possible and to create new ones where appropriate.

Most of North America's native bee species (about 70 percent, or very roughly 2,800 species) are ground nesters. These bees usually need direct access to the soil surface to excavate and access their nests. Ground-nesting bees seldom nest in rich soils, so poor quality sandy or loamy sand soils may provide fine sites. The great majority of ground-nesting bees are solitary, though some will share the nest entrance or cooperate to excavate and supply the nest. Still other species will nest independently, but in large aggregations with as many as 100s or 1000s of bees excavating nests in the same area.

Approximately 30 percent (around 1,200 species) of bees in North America are wood nesters. These are almost exclusively solitary. Generally, these bees nest in abandoned beetle tunnels in logs, stumps, and snags. A few can chew out the centers of woody plant stems and twigs, such as elderberry, sumac, and in the case of the large carpenter bees, agave even soft pines. Dead limbs, logs, or snags should be preserved wherever possible. Some wood-nesters also use materials such as mud, leaf pieces, or tree resin to construct brood cells in their nests.

Bumble bees are the native species usually considered to be social. There are about 45 species in North America. They nest in small cavities, such as abandoned rodent nests under grass tussocks or in the ground. Leaving patches of rough undisturbed grass in which rodents can nest will create future nest sites for bumble bees. Bunch grasses tend to provide better nesting habitat than does sod-forming varieties.

A secondary benefit of flower-rich foraging habitats is the provision of egg-laying sites for butterflies and moths. They lay their eggs on the plant on which their larva will feed once it hatches. Some butterflies may rely on plants of a single species or genus for host-plants (the monarch is an example, feeding only on species of milkweed, *Asclepias* sp.), whereas others may exploit a wide range of plants, such as some swallowtails (*Papilio* sp.), whose larvae can eat a range of trees, shrubs, and forbs. In order to provide egg-laying habitat for the highest number of butterflies and moths, growers should first provide plants that can be used by a number of species. Later those plants can be supplemented with host-plants for more specialized species. Consult a book on your region's butterfly fauna or contact local experts (Appendix I. A) to find out about species' specific needs.

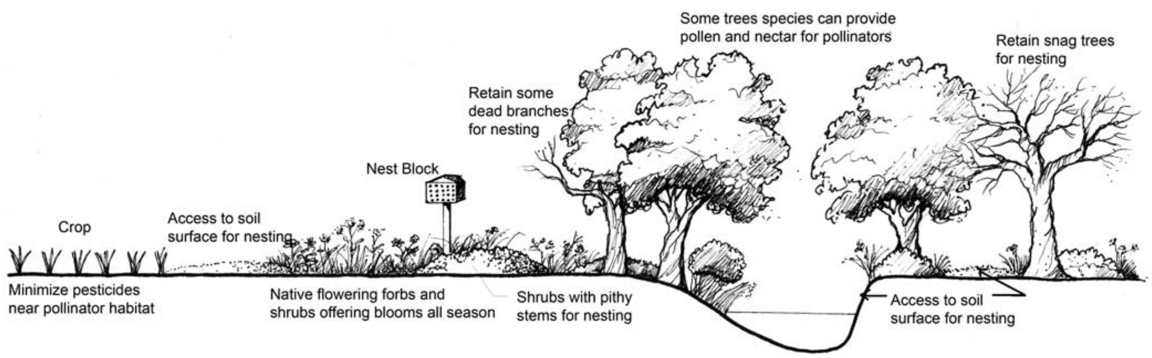


Figure 1. From: Agroforestry Note – 34: "Enhancing Nest Sites for Native Bee Crop Pollinators"

II. Protecting Pollinators and Their Habitat

When farmers and landowners recognize the potential pollinator habitat on their land, they can then work to protect these resources. In addition to conserving the food and nest sources of their resident pollinators, farmers can take an active role in reducing mortality of the pollinators themselves. While insecticides are an obvious threat to beneficial insects like bees, other farm operations or disturbance, such as burning and tilling, can also be lethal to pollinators.

A. Minimizing Pesticide Use

Pesticides are detrimental to a healthy community of native pollinators. Insecticides not only kill pollinators, but sub-lethal doses can affect their foraging and nesting behaviors, often preventing pollination. Herbicides can kill plants that pollinators depend on when crops are not in bloom, thus reducing the amount of foraging and egg-laying resources available.

If pesticides cannot be avoided, they should be applied directly on target plants to prevent drift, and broad-spectrum chemicals should be avoided if at all possible. Similarly, crops should not be sprayed while in bloom and fields should be kept weed free (or mowed just prior to insecticide applications) to discourage pollinators from venturing into the crop if it needs to be sprayed outside of the bloom period. Nighttime spraying, when bees are not foraging, is one way to reduce bee mortality. Periods of low temperatures may also be good for spraying since many bees are less active. However the residual toxicity of many pesticides tends to last longer in cool temperatures. For example, dewy nights may cause an insecticide to remain wet on the foliage and be more toxic to bees the following morning, so exercise caution.

In general, while pesticide labels may list hazards to honey bees, potential dangers to native bees are often not listed. For example, many native bees are much smaller in size than honey bees and affected by lower doses. Also, honey bee colonies may be covered or moved from a field, whereas wild natives will continue to forage and nest in spray areas.

The use of selective insecticides that target a narrow range of insects, such as *Bacillus thuringiensis* (*Bt*) for moth caterpillars, is one way to reduce or prevent harm to beneficial insects like bees. Generally dusts and fine powders that may become trapped in the pollen collecting hairs of bees and consequently fed to developing larvae are more dangerous than liquid formulations. Alternatives to insecticides are also available for some pests, such as pheromones for mating disruption, and kaolin clay barriers for fruit crops. Local cooperative extension personnel can often assist with the selection of less toxic pesticides, or with the implementation of integrated pest management (IPM) programs.

Landowners who encourage native plants for pollinator habitat will inevitably be providing habitat that also will host many beneficial insects that help control pests naturally, and may come to depend less on pesticides.

In addition to providing pollinator habitat, windbreaks, hedgerows, and conservation buffers can be effective barriers to reduce pesticide drift from adjacent fields. Spray drift can occur either as spray droplets or vapors—as happens when a volatile liquid changes to a gas. Factors effecting drift include weather, application method, equipment settings, and spray formulation. Weather related drift increases with temperature, wind velocity, convection air currents, and during temperature inversions.

Wind related drift can be minimized by spraying during early morning or in the evening when wind velocity is often lower. However even a light wind can cause considerable drift. Pesticide labels will occasionally provide specific guidelines on acceptable wind velocities for spraying a particular product.

Midday spraying is also less desirable because as the ground warms, rising air can lift the spray particles in vertical convection currents. These droplets may remain aloft for some time, and can travel many miles. Similarly, during temperature inversions spray droplets become trapped in a cool lower air mass and move laterally above the ground. Inversions often occur when cool night temperatures follow high day temperatures, and are usually worst in early morning before the ground warms. Low humidity and high temperature conditions also promote drift through the evaporation of spray droplets and the corresponding reduction of particle size. Optimal spray conditions for reducing drift occur when the air is slightly unstable with a very mild steady wind.

Spray application methods and equipment settings also strongly influence the potential for drift. Since small droplets are most likely to drift long distances, aerial applications and mist blowers should be avoided whenever possible. Standard boom sprayers should be operated at the lowest effective pressure and with the nozzles set as low as possible. For example, drop nozzles can be used to deliver insecticide within the crop canopy where it is less likely to be carried by wind currents.

Regardless of the chemical or type of application equipment used, sprayers should be properly calibrated to ensure that excess amounts of pesticide are not applied.

Nozzle type also has a great influence on the amount of drift a sprayer produces. Turbo jet, raindrop, and air-induction nozzles produce less drift than conventional nozzles. Standard flat fan or hollow cone nozzles are generally poor choices. Select nozzles capable of operating at low pressures (15 to 30 psi) to produce larger, heavier droplets.

Finally, oil-based chemical carriers produce smaller, lighter, droplets than water carriers and should also be avoided when possible. Consider using thickening agents if they are compatible with your pesticide.

B. Minimizing the Impact of Mowing, Haying, Burning, or Grazing

Only 1/3 or 1/4th of pollinator habitat should be burned, mowed, grazed, or hayed at any one time in order to protect overwintering pollinators and foraging larvae and adults, as well as other wildlife. This will allow for recolonization of the disturbed area from nearby undisturbed refugia, an important factor in the recovery of pollinator populations after disturbance. In order to maximize foraging and egg-laying opportunities, maintenance activities should be avoided while plants are in flower. Ideally, mowing or haying should be done only in the fall or winter. Similarly, late season burning (rather than spring) may be better for maintaining forb populations.

Unmowed hayfields of alfalfa and clover provide additional forage sources for pollinators. Photo: Toby Alexander, Vermont NRCS

C. Protecting Ground Nesting Bees

In order to protect nest sites of ground-nesting bees, tilling and flood-irrigating areas of bare or partially bare ground that may be occupied by nesting bees should be avoided. Grazing such areas can also disturb ground nests. Similarly, using fumigants like Chloropicrin for the control of soilborne crop pathogens (such as *Verticillium* wilt), or covering large areas with plastic mulch could be detrimental to beneficial ground nesting insects like bees.

Weed control alternatives to tillage include the use of selective crop herbicides, flame weeders, and hooded sprayers for between row herbicide applications.

D. Protecting Tunnel-Nesting Bees

Tunnel-nesting bees will make their homes in the abandoned tunnels of wood-boring beetles and the pithy centers of many woody plant stems. Allowing snags and dead trees to stand, so long as they do not pose a risk to property or people, and protecting shrubs with pithy or hollow stems, such as elderberry, raspberry, blackberry, boxelder, and sumac will go a long way towards supporting these solitary bees.

E. Supporting Managed Honey Bees

With a social lifecycle consisting of a single queen, her daughter-workers, and male drones whose only purpose is to mate, honey bees represent what most people think of when bees are discussed. Their habit of producing useful products like excess honey and wax has inspired people to keep them in man-made hives since at least 900 BC.

While not native to North America, the European honey bee (*Apis mellifera*) remains a crucial agricultural pollinator. Upon its introduction to North America in 1622, the honey bee initially thrived with feral colonies rapidly spreading across the continent by swarming from managed hives (the process by which an overgrown colony divides with half the colony flying away to find a new nest).

Unfortunately the subsequent accidental introduction of several major parasitic mites and bee diseases has slowly devastated both feral and managed honey bees in the U.S. In addition, the same habitat degradation and pesticide issues that have affected native bees, have also taken a dramatic toll on honey bee populations. The result is that with the exception of feral Africanized honey bees, which escaped from a research facility in Brazil in 1957 and slowly moved north through the southwestern U.S., few feral honey bees exist in North America. Similarly, the number of managed honey bee hives in the U.S. has declined by 50% since 1945, while the amount of crop acreage requiring bee pollination continues to rise.

Beekeepers have also suffered in recent years due to declining honey prices, the result of low cost imported honey. As a result many commercial beekeepers have increasingly turned to a pollination-for-hire business model, making much of their income by renting bees to growers who need their crops pollinated. The advantage of honey bees to growers is they can be transported long distances and because of their perennial nature, they can rapidly be deployed in large numbers at any time of year.

Solutions to the many parasite and disease problems facing honey bees will require additional research and new management practices. The issue of habitat degradation however can be addressed now. The same habitat enhancement guidelines outlined here that promote native bee populations, also promote honey bee populations and honey bee health. The critical factor for all bees is the presence of abundant pollen and nectar sources throughout spring, summer, and fall.

One habitat requirement for honey bees that is generally not as critical for native bees is access to water. Honey bees require water to cool their hives through evaporation (which they carry back to the hive in their stomach). Preferred water sources are shallow and calm with low approaches where bees can stand while they drink. It is imperative that water sources be clean and free of pesticides.

III. Enhancing and Developing New Pollinator Habitat

Landowners who want to take a more active role in increasing their population of resident pollinators can increase the available foraging habitat to include a range of plants that bloom and provide abundant sources of pollen and nectar throughout spring, summer, and fall.

Such habitat can take the form of designated pollinator meadows (“bee pastures”), demonstration gardens, orchard understory plantings, hedgerows and windbreaks with flowering trees and shrubs, riparian and rangeland re-vegetation efforts, flowering cover crops and green manures, and other similar efforts.

Where possible, locally native plants are often preferred over non-native plants for their ease of establishment, greater wildlife value, and their mutually beneficial co-evolution with native pollinators. Non-native plants may be suitable however on disturbed sites, for specialty uses such as cover cropping, and where native plants are not available. Mixtures of native and non-native plants are also possible, so long as non-native species are naturalized and not invasive. It should be noted that a number of common, naturalized species such as birdsfoot trefoil, white clovers and alfalfa provide a good source of nectar to pollinators and are easily established, particularly in an agricultural setting.

A. Site Selection

Site selection for installing new pollinator-enhancement habitat should begin with a thorough assessment of exposure (including aspect and plant shade) and soil conditions, but also must take into account land use and available resources.

1. ASPECT: In general, areas of level ground, with full sun throughout the day, and good air circulation offer the most flexibility. East and south-facing slopes may also be acceptable as long as erosion is controlled during the installation process. Unless the site is located near a large body of water, west-facing slopes in many climates are often subjected to hot afternoon sunlight, and drying winds. Under such conditions west-facing slopes tend to be naturally dominated by grasses, which are usually of little food value to pollinators, but may host nest sites for ground-nesting bees and bumble bees. North-facing slopes are often cooler and tend to be dominated by trees.

2. SUN EXPOSURE: Since some plants require full sun or shaded conditions to thrive, the planting design should allow for sun-loving plants to remain in full sun as the habitat matures. Plantings can also be installed in several phases, for example allowing trees and shrubs to develop an over-story prior to planting shade-loving herbaceous plants below. Generally, plants will flower more, and thus provide greater amounts of nectar and pollen, when they receive more sunlight than when they are fully shaded.

3. SOIL CHARACTERISTICS: Soil type is also an important consideration when selecting a site, with some plants favoring particular soil textures such as sand, silt, clay, or loam. Drainage, salinity, pH, organic content, bulk density, and compaction are some of the other factors that will influence plant establishment. Many of these factors can be determined from local soil surveys, and the NRCS Web Soil Survey (http://websoilsurvey.nrcs.usda.gov/app/). Planning should emphasize those plants that will be adapted for the particular soil conditions faced.

Fertility, soil pathogens, the presence of rhizobium bacteria, and previous herbicide use should also be considered during the planning process. Soil fertility will be most critical during early plant establishment, especially on previously cropped land. As the habitat matures, few if any inputs should be required, especially if native plants are selected. Similarly, previously cropped land may harbor soilborne pathogens that may inhibit plant development. Where such conditions exist, pathogen-resistant plant species should be considered. Conversely some soil microorganisms, such as rhizobium bacteria, are essential for the successful establishment of certain types of plants, legumes for example. If rhizobium bacteria are absent in the soil, specially inoculated seed is often available. Finally, herbicides like atrazine and trifluralin can inhibit seed germination. These chemicals, soil pathogens, beneficial microorganisms, and soil fertility can all be tested for by state, and extension soil laboratories. At a minimum, a soil test is recommended to determine fertility.

4. ADJACENT LAND USE: Along with exposure and soil conditions, adjacent plant communities and existing land use activities should be considered. For example even if weeds are eliminated prior to planting, the presence of invasive plants adjacent to the restored habitat may result in a persistent problem that requires ongoing management. Adjacent cropland can also present a challenge unless the enhancement site is protected from herbicide drift.

5. USING MARGINAL LAND: Some otherwise marginal land, such as septic fields and mound systems, can be perfectly suited for pollinator plantings. While trees may be problematic on such sites, forbs will generally not penetrate pipes or clog systems. As an added benefit, plants on these sites may help absorb excess nutrients from wastewater.

Ditches, field buffer strips, and grassed waterways can also be planted with pollinator-friendly plants rather than turf grass. For example legumes like clover and alfalfa can be used in these situations along with grasses.

6. SIZE AND SHAPE: The larger the planting area, the greater the potential benefit to pollinator species. An area considered for enhancement should be at least one-half acre in size, with two acres or more providing even greater benefits. With herbaceous plantings, large, square planting blocks will minimize the edge around the enhancement site and thus reduce susceptibility to invasion by weeds surrounding the perimeter. However, linear corridor plantings (e.g. along a stream or a hedgerow, or a crop border) will often be more practical. Where these linear plantings are used, consider a minimum width of 10 feet.

Regardless of planting shape, to build sufficient resident pollinator numbers for reliable pollination services, consider requiring 1 or 2 acres for every 25 acres of cropped field.

B. Habitat Design

When designing a pollinator planting, first consider the overall landscape and how the new habitat will function with adjacent crops. From there focus on the specifics of the planting, such as species diversity, bloom time, plant density, and the inclusion of grasses for weed control and soil stabilization.

1. LANDSCAPE CONSIDERATIONS: The first step in habitat design should be a consideration of how the area can work with adjacent landscape features.

For example, is the new habitat area close enough to crops requiring pollination to be of significant value? Remember that flight distances of small native bees might be as little as 500 feet, while larger bumble bees may forage up to a mile away from their nest. Thus, crops that depend heavily upon bumble bees for pollination, such as cranberries or blueberries, might still benefit from pollinator habitat located some distance from the field (although even bumble bees prefer habitat as close to the crop as possible). This sort of arrangement would minimize the encroachment into the crop by unwanted pollinator plants while still supporting a strong local population of bees.

Similarly, is the new habitat located near existing pollinator populations that can “seed” the new area? For example, fallow areas, existing wildlands, or unmanaged landscapes can all make a good starting place for habitat enhancement. In some cases these areas may already have abundant nest sites, such as fallen trees or stable ground, but lack the floral resources to support a large pollinator population. Be aware of these existing habitats and consider improving them with additional pollinator plants or nesting sites, or constructing new enhancement areas adjacent to them.

2. DIVERSE PLANTINGS: Diversity is a critical factor in the design of pollinator enhancement areas. Flowers should be available throughout the entire growing season, or at least whenever adjacent crops needing pollination are not in bloom. It is desirable to include a diversity of plants with different flower colors, sizes and shapes as well as varying plant heights and growth habits to encourage the greatest numbers and diversity of pollinators. Most bee species are generalists, feeding on a range of plants throughout their life cycle.

Many others, including some important crop pollinators, only forage on a single family or even genus of plants.

Diverse plantings of native forbs, such as wild indigo (*Baptisia alba*) should be prioritized to support the greatest abundance and diversity of pollinators. Photo: Eric Mader, The Xerces Society.

Butterflies have a long tongue that can probe tubular flowers. Therefore, choose plants with a variety of flower shapes in order to attract a diversity of pollinators. Color is another consideration. Bees typically visit flowers that are purple, violet, yellow, white, and blue. Butterflies visit a similarly wide range of colors, including red, whereas flies are primarily attracted to white and yellow flowers. Thus, by having several plant species flowering at once, and a sequence of plants flowering through spring, summer, and fall, habitat enhancements can support a wide range of pollinator species that fly at different times of the season.

Diverse plantings that resemble natural native plant communities are also the most likely to resist pest, disease, and weed epidemics and thus will confer the most pollinator benefits over time. Species found in association with each other in local natural areas are likely to have the same light, moisture, and nutrient needs such that when these species are put into plantings they are more likely to thrive together.

The level of plant community diversity can be measured in several ways. One system used in managed woody plant ecosystems is the *10-20-30 Rule*. This rule states that a stable managed plant community (i.e. one able to resist insect and disease epidemics) should contain no more than 10% of a single plant species, no more than 20% of a single genera, and no more than 30% of a single family.

3. PLANT DENSITY AND BLOOM TIME: Plant diversity should also be measured by the number of plants flowering at any given time. Researchers in California have found that when eight or more species of plants with different bloom times are grouped together at a single site, they tend to attract a significantly greater abundance and diversity of bee species. Therefore, at least three different pollinator plants within each of three blooming periods are recommended (i.e. early, mid or late season - refer to the tables in Section VI for more information). Under this plan at least nine blooming plants should be established in pollinator enhancement sites, although in some studies bee diversity continues to rise with increasing plant diversity and only starts to level out when twenty or more different flower species occur at a single site.

It is especially important to include plants that flower early in the season. Many native bees, such as bumble bees and some sweat bees, produce multiple generations each year. More forage available early in the season will lead to greater reproduction and more bees in the middle and end of the year. Early forage may also encourage bumble bee queens that are emerging from hibernation to start their nests nearby, or simply increase the success rate of nearby nests. Conversely, it is also important to include plants that flower late in the season to ensure that queen bumble bees are strong and numerous going into winter hibernation.

Plant clusters of a single species when possible. Research suggests that clump-plantings of at least three foot by three foot blocks of an individual species (that form a solid block of color when in flower) are more attractive to pollinators than when a species is widely and randomly dispersed in smaller clumps. Even larger single-species clumps (e.g. a single species cluster of perennials or shrubs more than 25 square feet in size) may be more even ideal for attracting pollinators and providing efficient foraging.

4. INCLUSION OF GRASSES: Herbaceous plantings should include at least one native bunch grass or sedge adapted to the site in addition to the three or more forbs or shrubs from each of the three bloom-periods (i.e. spring, summer, and fall - refer to the tables in Section VI). This scenario results in a minimum of 10 plant species per planting. Strive for an herbaceous plant community that mimics a local native ecosystem assemblage of plant density and diversity (generally with a greater diversity of forbs) to maximize pollinator habitat. Most native plant communities generally contain at least one dominant grass or sedge in their compositions. These grasses and sedges often provide forage resources for beneficial insects (including larval growth stages of native butterflies), potential nesting sites for colonies of bumble bees, and possible overwintering sites for beneficial insects, such as predaceous ground beetles. The combination of grasses and forbs also form a tight living mass that will resist weed colonization. Grasses are also essential to produce conditions suitable for burning, if that is part of the long-term management plan.

Care should be taken however that grasses do not take over pollinator sites. Anecdotal evidence suggests that tall grasses crowd out forbs more easily than short grasses, and that cool season grasses are more competitive against many forbs than warm season grasses. Seeding rates for grasses should also not exceed seeding rates for forbs. Planting in the fall, rather than spring, will also favor forb development over grasses.

C. Plant Selection and Seed Sources

Choose plants with soil and sunlight requirements that are compatible with the site where they will be planted. The plant tables in Section VI provide a starting point for selecting widely distributed and regionally appropriate pollinator plants. If these plants are not available, other closely related species might serve as suitable replacements.

1. NATIVE PLANTS: Native plants are adapted to the local climate and soil conditions where they naturally occur. Native pollinators are generally adapted to the native plants found in their habitats. Conversely, some common horticultural plants do not provide sufficient pollen or nectar rewards to support large pollinator populations. Similarly, non-native plants may become invasive and colonize new regions at the expense of diverse native plant communities.

Native plants are advantageous because they generally: (1) do not require fertilizers and require fewer pesticides for maintenance; (2) require less water than other non-native plantings; (3) provide permanent shelter and food for wildlife; (4) are less likely to become invasive than non-native plants; and (5) promote local native biological diversity.

Using native plants will help provide connectivity for native plant populations, particularly in regions with fragmented habitats. By providing connectivity of plant species across the landscape, the potential is increased for these species to move in the landscape in relation to probable future climatic shifts.

2. SEED SOURCES: Where available and economical, native plants and seed should be procured from "local eco-type" providers. Local eco-type refers to seed and plant stock harvested from a local source (often within a few hundred miles). Plants selected from local sources will generally establish and grow well because they are adapted to the local climatic conditions. Depending on the location, state or local regulations may also govern the transfer of plant materials beyond a certain distance (sometimes called *Seed Transfer Zones*). Similarly, commercially procured seed should be certified by the state Crop Improvement Agency if possible. Seed certification guarantees a number of quality standards, including proper species, germination rate, and a minimum of weed seed or inert material.

3. TRANSPLANTS: In addition to seed, enhancement sites can be planted with plugs, or in the case of woody plants, container grown, containerized, bare-root, or balled and burlaped materials.

Herbaceous plants purchased as plugs have the advantage of rapid establishment and earlier flowering, although the cost of using plugs can be prohibitive in large plantings. Transplanted forbs also typically undergo a period of shock during which they may need mulching and supplemental water to insure survival.

Woody plants may also undergo a period of transplant shock and need similar care. In general, container grown and balled and burlaped woody plants have a higher survival rate and are available in larger sizes. They are also generally more expensive than bare-root or containerized plants. Containerized trees and shrubs are plants that were either hand-dug from the ground in a nursery setting, or were harvested as bare-root seedlings, then placed in a container. Although the cost of containerized plants is typically low, they should be examined for sufficient root mass before purchase to ensure successful establishment.

4. AVOID NUISANCE PLANTS: When selecting plants, avoid ones that act as alternate or intermediate hosts for crop pests and diseases. Similarly economically important agricultural plants (or closely related species) are generally a poor choice for enhancement areas, because without intensive management, they may serve as a host reservoir for insect pests and crop diseases. For example commercial apple growers may prefer not to see apple trees used in adjacent conservation plantings for wildlife because the trees are likely to harbor various insect pests and disease spores. Similarly cranberry growers may prefer not to have wild blueberry planted near their operations.

5. APPLICATIONS FOR NON-NATIVE PLANT MATERIALS: While in most cases native plants are preferred, non-native ones may be suitable for some applications, such as annual cover crops, buffers between crop fields and adjacent native plantings, or areas of low cost, temporary bee pasture plantings that also attract beneficial insects which predate or parasitize crop pests. For more information on suitable non-native plants for pollinators, see the table in Section VI.

D. Creating Artificial Nest Sites

There are many successful ways to provide nesting sites for different kinds of native bees, from drilled wooden blocks to bundles of reeds to bare ground or adobe bricks. The Xerces Society's *Pollinator Conservation Handbook* provides detailed information on how to build artificial nest sites. Generally, increasing nesting opportunities will result in at least a short-term increase in bee numbers.

Most native bees nest in the ground. The requirements of one species, the alkali bee (*Nomia melanderi*) are so well understood that artificial nesting sites are created commercially to provide reliable crop pollination for alfalfa in eastern Washington and Idaho. Unlike the alkali bee, however, the precise conditions needed by most other ground-nesting bees are not well known. Some species nest in the ground at the base of plants, and others prefer smooth packed bare ground. Landowners can create conditions suitable to a variety of species by maximizing areas of undisturbed, untilled ground and/or constructing designated areas of semi-bare ground, or piles of soil stabilized with bunch grasses and wildflowers. Such soil piles might be constructed with soil excavated from drainage ditches or silt traps. Different species of bees prefer different soil conditions, although research shows that many ground nesting bees prefer sandy, loamy sand or sandy loam soils.

The majority of native bees nest underground as solitary individuals. From above ground these nests often resemble ant hills. Photo: Eric Mader, The Xerces Society.

In general these constructed ground nest sites should receive direct sunlight, and dense vegetation should be removed regularly (through very light disking or herbicide use), making sure that some patches of bare ground are accessible. Once constructed, these nest locations should be protected from digging and compaction.

Colonization of these nest sites will depend upon which bees are already present in the area, their successful reproduction and population growth, and the suitability of other nearby sites. Ground-nesting bee activity can be difficult to observe because there is often little above ground evidence of the nests. Tunnel entrances usually resemble small ant mounds, and can range in size from less than 1/8 inch in diameter to almost 1/2 inch in diameter, depending on the species.

In contrast to ground-nesting bees, other species such as leafcutter and mason bees naturally nest in beetle tunnels and similar holes in dead trees. Artificial nests for these species can be created by drilling a series of holes into wooden blocks. A range of hole diameters will encourage a diversity of species, providing pollination services over a longer period of time.

Such blocks can be made by drilling nesting holes between 3/32” and 3/8” in diameter, at approximately 3/4” centers, into the side of a

A mason bee (*Osmia lignaria*) closes off the entrance to its hollow stem nest with mud. Photo: Mace Vaughan, The Xerces Society.

block of preservative-free lumber. The holes should be smooth inside, and closed at one end. The height of the nest is not critical—8” or more is good—but the depth of the holes is. Holes less than 1/4” diameter should be 3-4” deep. For holes 1/4” or larger, a 5-6” depth is best.

Nest blocks should be hung in a protected location where they receive strong indirect sunlight and are protected from rain. Large blocks tend to be more appealing to bees than small ones, and colonization is often more successful when blocks are attached to a large visible landmark (such as a building), rather than hanging from fence posts or trees.

Many tunnel-nesting bees do not forage far from their nest site, so multiple blocks may be useful adjacent to cropland. For areas where natural nest cavities may be limited, supply at least two to three blocks per acre, each with at least 20 drilled holes.

In addition to wooden blocks, artificial nests can be constructed with bundles of paper straws, cardboard tubes, or sections of reed or bamboo cut so that a natural node forms the inner wall of the tunnel.

Extensive information constructing these types of nests is widely available. In order to be sustainable, artificial nests will need routine management, and regular cleaning to prevent the build-up of bee parasites and diseases.

A drilled bee nest block. Photo: Toby Alexander, Vermont NRCS.

IV. Management of New Pollinator Habitat

Habitat plantings for pollinators should remain undisturbed to the greatest extent possible throughout the growing season so that insects can utilize flower pollen and nectar resources (for adult stages) and vegetative parts of plants for food and cover resources (for immature/larval stages). If site maintenance must occur during the growing season in order to maintain the open, species rich habitat preferred by pollinators, establish a system for managing a small percentage (30% or less) of the site each year on a three to five year rotation. This will allow for re-colonization of disturbed habitat from the surrounding area.

Early successional habitat is a conservation priority in the Northeast because many species of wildlife that depend on these habitats are experiencing population declines. These habitats are typically transitional and require different levels of disturbance to be maintained. Examples of early successional habitats include weedy areas, grasslands, old fields, blueberry barrens, shrub thickets, and young forest. Disturbance and management can be accomplished through mowing, brush hogging, burning, cutting, grazing, herbicide application, and other methods.
While existing efforts to create and manage these habitats has been focused on birds and mammals, these managed areas also provide excellent habitat for pollinators.

Early successional habitats can provide a diversity of native and naturalized grasses and forbs that provide both food (pollen and nectar) and cover. Disturbance loving woody species such as the cherries, willow, blueberry, rubus sp., dogwood, viburnums and spirea provide an important source of nectar and/or pollen. Many of these woody species flower in spring making them very important for successful pollinator reproduction later in the season. Additionally, early successional habitats with a woody component provide many important cover species for tunnel nesting bees such as elderberry, sumac, blackberry, and raspberry.

For existing early successional areas, disturb as little of the area during the growing season as possible (30% or less) to maintain or manage for a diversity of grasses, forbs, shrubs and trees. Ideally, disturbance should not occur every year but be sure to prioritize a management scenario that will maintain the desired habitat components. Practice rotational mowing which entails mowing different parts of a field each year or entry. Remove or girdle large undesirable trees that begin to shade out the more desirable forbs and shrubs. Control invasive plants to lessen any negative impacts to the habitat.

When creating a new early successional area, focus attention on large blocks of habitat. Five acre blocks or larger will provide the most benefit to the greatest number of species both vertebrate and invertebrate. Larger openings with plenty of sun will favor shade intolerant plant species that are often sought by pollinators and other wildlife. To be most effective, new habitat areas should be created next to existing open habitats. For additional information, refer to the NRCS Conservation Practice Standard 647 Early Successional Habitat Development and Management and the NRCS Fish and Wildlife Habitat Management Leaflet Number 41.

Where livestock are available, controlled, rotational grazing may also be a viable option for managing the plant community. Grazing should generally occur at only light intensity, or at least with a long rest-rotation schedule of grazing.

Similarly, no single area should be burned more frequently than every two years. To facilitate these limited burns, temporary firebreaks can be created as needed, or they can be designed into the planting from the beginning by planning permanent firebreaks using the NRCS Conservation Practice Standard 394, Firebreak, that separate the habitat into multiple sections.

Pollinator Habitat and NRCS Practices

The Natural Resources Conservation Service supports the use of native species in many of their conservation practices that involve seeding or transplanting. Selecting pollinator-friendly native species for these practices can provide added conservation benefits. Many conservation practices also can support the inclusion or management of nest sites for native bees.

Many of these practices have a purpose, criteria or considerations for enhancing wildlife (including pollinators). However, an enhancement for wildlife should not compromise other intended functions of the practice. For example, plants attractive to pollinators could be used in a grassed waterway practice, but the planting should not interfere with the hydraulic function of the practice and primary objective of stabilizing the waterway against erosion.

Some practices that could include pollinator friendly supplements include:

Conservation Practice Name (Units)	Code	Pollinator Notes
Alley Cropping (Ac.)	311	Can include native trees or shrubs or row covers (e.g. various legumes) that provide nectar or pollen (see *Agroforestry Note 33*).
Brush Management (Ac.)	314	Reduction of noxious woody plants can be used to help maintain pollinator-friendly early successional habitat.
Channel Bank Vegetation (Ac.)	322	Can include diverse flowering trees, shrubs, and forbs. Channel banks provide a unique opportunity to supply early-flowering willow and, in dry areas, late flowering native forbs (e.g. goldenrod (*Solidago* spp.).
Conservation Cover (Ac.)	327	Can include diverse forbs (e.g. various legumes) to increase plant diversity and ensure flowers are in bloom for as long as possible, providing nectar and pollen throughout the season.
Conservation Crop Rotation (Ac.)	328	Can include rotation plantings of forbs that provide abundant forage for pollinators (e.g. various legumes, buckwheat (*Fagopyrum* spp.), phacelia (*Phacelia* spp.*)*, etc.). Moving insect-pollinated crops no more than 250 meters (750 feet) during the rotation may help maintain local populations of native bees that have grown because of a specific crop or conservation cover. Growers may want to consider crop rotations that include a juxtaposition of diverse crops with bloom timing that overlaps through the season to support pollinator populations. Growers might also consider eliminating, minimizing insecticides and/or using bee-friendly insecticides in cover crop rotations.
Constructed Wetland (Ac.)	656	Constructed wetlands can include plants that provide pollen and nectar for native bees and other pollinators. Possible plant genera with obligate or facultative wetland species include: *Rosa* spp., *Ribes* spp., *Salix* spp., *Rubus* spp., *Crataegus* spp., *Spirea* spp., *Solidago* spp., *Cornus* spp. Look for appropriate wetland plants from these genera for your region.
Contour Buffer Strips (Ac.)	332	Can include diverse legumes or other forbs that provide pollen and nectar for native bees. In addition, the recommendation to mow only every two or three years to benefit wildlife also will benefit nesting bumble bees. To protect bumble bee nests, mowing should occur in the late fall when colonies have died for the year and queens are overwintering.
Cover Crop (Ac.)	340	Can include diverse legumes or other forbs that provide pollen and nectar for native bees. Look for a diverse mix of plant species that overlap in bloom timing to support pollinators throughout the year. Some examples of cover crops that are utilized by bees include clover (*Trifolium* spp.), phacelia (*Phacelia* spp.), and buckwheat (*Fagopyrum* spp.). Many "beneficial insect" cover crop blends include plant species that will also provide forage for pollinators.
Critical Area Planting (Ac.)	342	Can include plant species that provide abundant pollen and nectar for native bees and other pollinators.
Early Successional Habitat Development/Management (Ac.)	647	This management practice is important for maintaining prime open and sunny habitat for pollinators. Note: To minimize damage to pollinator populations, disturbance practices should be implemented only every 2 to 3 years and, ideally, on only 30 % or less of the overall site. This allows for recolonization from non-treated habitat. For example, mowing or burning 1/3 of the site every 2 or 3 years, on a 3-year

Conservation Practice Name (Units)	Code	Pollinator Notes
		cycle. When possible, disturbance should be implemented during late fall and winter when most pollinators are inactive.
Field Border (Ac.)	386	Can include diverse legumes or other forbs that provide pollen and nectar for native bees. Strive for a mix of forbs and shrubs that come into bloom at different times throughout the year. Site management (for example, mowing) should occur in the fall to minimize impacts on pollen and nectar sources used by pollinators. If a goal is to create potential nesting habitat for bees, mowing, combined with no tillage, can maintain access to the soil surface that may provide nesting habitat for ground-nesting solitary bees. Alternatively, allowing field borders to become overgrown (e.g. with native bunch grasses) may provide nesting habitat for bumble bees.
Filter Strip (Ac.)	393	Can include legumes or other forbs that provide pollen and nectar for native bees. Look for a diverse mix of plant species that come into bloom at different times throughout the year. Site management (for example, mowing or burning) should occur in the fall to minimize impacts on pollinators.
Forest Stand Improvement (Ac.)	666	Can help maintain open understory and forest gaps that support diverse forbs and shrubs that provide pollen and nectar for pollinators. Standing dead trees may be kept and drilled with smooth 3- to 6-inch deep holes to provide nesting sites for bees.
Grassed Waterway (Ac.)	412	Can include diverse legumes or other forbs that provide pollen and nectar for native bees. In dry regions, these sites may be able to support flowering forbs with higher water requirements and thus provide bloom later in the summer.
Hedgerow Planting (Ft.)	422	Can include forbs and shrubs that provide pollen and nectar for native bees. Look for a diverse mix of plant species that come into bloom at different times throughout the year. Bee nesting sites also may be incorporated, including semi-bare ground or wooden block nests. Including strips of unmowed grasses and forbs along the edge of the hedgerow may provide nesting opportunities for bumble bees. This practice also can help reduce drift of pesticides onto areas of pollinator habitat.
Herbaceous Wind Barriers (Ft.)	603	Can include diverse forbs and shrubs that provide pollen and nectar for native bees. Look for a diverse mix of plant species that come into bloom at different times throughout the year.
Multi-Story Cropping (Ac.)	379	Woody plants may be chosen that supply pollen and nectar for pollinators. Look for mixes of plants that flower at different times throughout the growing season and can support populations of pollinators over time.
Pasture and Hay Planting (Ac.)	512	Can include diverse legumes (e.g. alfalfa, clovers) or other forbs that, when in bloom, provide pollen and nectar for native bees.
Pest Management (Ac.)	595	Biological pest management can include plantings that attract beneficial insects that predate or parasitized crop pests. These plantings can also benefit pollinator species. Plants commonly used for pest management that also benefit bees include: yarrow (*Achillea* spp.), phacelia (*Phacelia* spp.), and sunflowers (*Helianthus* spp.). Can include legumes or other forbs that provide pollen and nectar for native bees. Look for a diverse mix of plant species that come into bloom at different times throughout the year.

Conservation Practice Name (Units)	Code	Pollinator Notes
Prescribed Burning (Ac.)	338	Can greatly benefit pollinators by maintaining open, early successional habitat. Note: It is best if (a) only 30% or less of a site is burned at any one time to allow for recolonization by pollinators from adjacent habitat and (b) if burning occurs when pollinators are least active, such as when most plants have senesced or in the fall.
Prescribed Grazing (Ac.)	528	Can help maintain early successional habitat and its associated flowering plants. Can help provide for a stable base of pollinator plant species. Note: Properly managed grazing can sustain and improve all pollinator forage (pollen and nectar sources) and potential nesting sites for ground-nesting and cavity-nesting bees. Provide rest-rotation in pastures/fields during spring and summer when pollinators are most active.
Residue and Tillage Management, No-Till/Strip Till/Direct Seed (Ac.)	329	Leaving standing crop residue can protect bees that are nesting in the ground at the base of the plants they pollinate. Tillage digs up these nests (located 0.5 to 3 feet underground) or blocks emergence of new adult bees the proceeding year.
Restoration and Management of Rare and Declining Habitats (Ac.)	643	Can be used to provide diverse locally grown native forage (forbs, shrubs, and trees) and nesting resources for pollinators. Many specialist pollinators that are closely tied to rare plants or habitats may significantly benefit from efforts to protect rare habitat. In addition, certain rare plants require pollinators to reproduce. Note: Pollinator plants should only be planted if they were part of the rare ecosystem you are trying to restore.
Riparian Forest Buffer (Ac.)	391	Can include trees, shrubs, and forbs especially chosen to provide pollen and nectar for pollinators. This practice also can help reduce drift of pesticides onto areas of pollinator habitat.
Riparian Herbaceous Cover (Ac.)	390	Can include diverse forbs that provide pollen and nectar for native bees. In drier parts of the U.S., many of these forbs flower in the late summer and fall, when forage is needed most.
Silvopasture Establishment (Ac.)	381	If grazing intensity is low enough to allow for plants to flower, this practice can include legumes and other forbs that provide pollen and nectar for native bees. Trees and shrubs that provide pollen and nectar also can be planted.
Stream Habitat Improvement and Management (Ac.)	395	Plants chosen for adjoining riparian areas can include trees, shrubs, and forbs that provide pollen and nectar for pollinators. Maximizing plant diversity along riparian corridors will result in more pollinators and other terrestrial insects to feed fish in the streams.
Streambank and Shoreline Protection (Ft.)	580	If vegetation is used for streambank protection, plants can include trees, shrubs, and forbs (for example, willow (*Salix* spp.), dogwood, (*Cornus* spp.) and goldenrod (*Solidago* spp.)) especially chosen to provide pollen and nectar for pollinators.
Stripcropping (Ac.)	585	Can include diverse legumes or other forbs that provide pollen and nectar for native bees. Also, if insect pollinated crops are grown, plants used in adjacent strips of vegetative cover may be carefully chosen to provide a complementary bloom period to the crop, such that the flowers available in the field are extended over a longer period of time.

Conservation Practice Name (Units)	Code	Pollinator Notes
Tree/Shrub Establishment (Ac.)	612	Can include trees and shrubs especially chosen to provide pollen and nectar for pollinators, or host plants for butterflies.
Upland Wildlife Habitat Management (Ac.)	645	Can include managing for pollinator forage or pollinator nest sites, such as nest blocks or snags for cavity nesting bees, or overgrown grass cover for bumble bees.
Vegetative Barriers (Ft.)	601	Can include plants that provide pollen and nectar for pollinators as long as they are of a stiff, upright stature for impeding surface water flow.
Vegetated Treatment Area (Ac.)	635	Can include plants that provide pollen and nectar for pollinators.
Wetland Enhancement (Ac.)	659	Wetland and adjacent upland can include trees, shrubs, and forbs especially chosen to provide pollen and nectar for pollinators. Snags can be protected or nest blocks for bees erected. Some forbs used for enhancement will require pollinators to reproduce.
Wetland Restoration (Ac.)	657	Wetland and adjacent upland can include trees, shrubs, and forbs especially chosen to provide pollen and nectar for pollinators. Snags can be protected or nest blocks for bees erected. Some forbs used for restoration will require pollinators to reproduce.
Wetland Wildlife Habitat Management (Ac.)	644	Wetland and adjacent upland can include trees, shrubs, and forbs especially chosen to provide pollen and nectar for pollinators. Snags can be protected or nest blocks for bees erected.
Windbreak/Shelterbelt Establishment (Ft.)	380	Can include trees, shrubs, and forbs especially chosen to provide pollen and nectar for pollinators. Can also be a site to place nesting structures for native bees. Windbreaks and shelter belts also will help reduce drift of insecticides on to a site.
Windbreak/Shelterbelt Renovation (Ft.)	650	Can include trees, shrubs, and forbs especially chosen to provide pollen and nectar for pollinators. If appropriate, dead trees and snags may be kept or drilled with holes to provide nesting sites for bees.

Conversely, various pollinator requirements are supported by the following conservation practices:

Pollinator Resource	Code and Conservation Practice Name (Units)			
Forage (diverse sources of pollen and nectar that support pollinators from early in the spring to late in the fall)	311	Alley Cropping (Ac.)	643	Restoration and Management of Rare and Declining Habitats (Ac.)
	322	Channel Bank Vegetation (Ac.)	391	Riparian Forest Buffer (Ac.)
	327	Conservation Cover (Ac.)	390	Riparian Herbaceous Cover (Ac.)
	328	Conservation Crop Rotation (Ac.)	381	Silvopasture Establishment (Ac.)
	656	Constructed Wetland (Ac.)	395	Stream Habitat Improvement and Management (Ac.)
	332	Contour Buffer Strips (Ac.)	580	Streambank and Shoreline Protection (Ft.)
	340	Cover Crop (Ac.)	585	Stripcropping (Ac.)
	342	Critical Area Planting (Ac.)	612	Tree/Shrub Establishment (Ac.)
	386	Field Border (Ac..)	645	Upland Wildlife Habitat Management (Ac.)
	393	Filter Strip (Ac.)	601	Vegetative Barriers (Ft.)
	412	Grassed Waterway (Ac.)	659	Wetland Enhancement (Ac.)
	422	Hedgerow Planting (Ft.)	657	Wetland Restoration (Ac.)
	603	Herbaceous Wind Barriers (Ft.)	644	Wetland Wildlife Habitat
	379	Multi-Story Cropping (Ac.)		
	512	Pasture and Hay Planting (Ac.)		
	595	Pest Management (Ac.)		
	409	Prescribed Forestry (Ac.)		
	528	Prescribed Grazing (Ac.)		

		Management (Ac.) 380 Windbreak/Shelterbelt Establishment (Ft.) 650 Windbreak/Shelterbelt Renovation (Ft.)
Nest sites (stable ground, holes in wood, cavities for bumble bees, or overwintering sites for bumble bee queens)	322 Channel Bank Vegetation (Acre) 656 Constructed Wetland (Ac.) 332 Contour Buffer Strips (Ac.) 342 Critical Area Planting (Ac.) 647 Early Successional Habitat (Ac.) 386 Field Border (Ac.) 422 Hedgerow Planting (Ft.) 409 Prescribed Forestry (Ac.) 329 Residue & Tillage Management, No-Till/Strip Till/Direct Seed (Ac.) 643 Restoration and Management of Rare and Declining Habitats (Ac.)	391 Riparian Forest Buffer (Ac.) 612 Tree/Shrub Establishment (Ac.) 645 Upland Wildlife Habitat Management (Ac.) 659 Wetland Enhancement (Ac.) 657 Wetland Restoration (Ac.) 644 Wetland Wildlife Habitat Management (Ac.) 380 Windbreak/Shelterbelt Establishment (Ft.) 650 Windbreak/Shelterbelt Renovation (Ft.)
Pesticide protection (refuge from spray, buffers to drift, etc.)	322 Channel Bank Vegetation (Ac.) 656 Constructed Wetland (Ac.) 342 Critical Area Planting (Ac.) 386 Field Border (Ac.) 422 Hedgerow Planting (Ft.)	391 Riparian Forest Buffer (Ac.) 657 Wetland Restoration (Ac.) 380 Windbreak/Shelterbelt Establishment (Ft.)
Site management for pollinators	314 Brush Management (Ac.) 647 Early Successional Habitat Development or Management (Ac.) 595 Pest Management (Ac.) 338 Prescribed Burning (Ac.) 409 Prescribed Forestry (Ac.) 528 Prescribed Grazing (Ac.)	643 Restoration and Management of Rare and Declining Habitats (Ac.) 645 Upland Wildlife Habitat Management (Ac.) 644 Wetland Wildlife Habitat Management (Ac.)

Financial Resources

Defenders of Wildlife maintains a summary of state and regional financial incentive programs for conservation projects through the Biodiversity Partnership project. A number of these incentive programs may be suitable for pollinator conservation and could be used in conjunction with NRCS conservation efforts. Information can be found at http://www.biodiversitypartners.org/state/index.shtml

Plant Tables

Below are tables with information about native and non-native trees, shrubs, wildflowers, and grasses to consider for plantings to enhance pollinator habitat. These tables include brief information on bloom timing and the basic cultural needs of the plants. The information provided is a starting point for determining plants to use for a particular project. To find species that are available and/or hardy for a specific location, consult your state NRCS Major Land Resource Area (MLRA) plant list or other plant zone criteria. Additional information such as the geographic distribution and cultural requirements for various plants is available from species fact sheets like those found at the USDA PLANTS database (http://plants.usda.gov/java/factSheet).

These tables are not exhaustive; many other plants are good for bees. These lists were limited to those plants thought to require insect pollination and to be relatively widespread and commonly found in the public marketplace as seed or nursery stock.

I. Native Plant Species

The cost of native plants may appear to be more expensive than non-native alternatives when comparing costs at the nursery, but when the costs of maintenance (e.g. weeding, watering, fertilizing) are calculated over the long-term, native plantings can ultimately be more cost-efficient for pollinator enhancement. Native plantings also give the added benefit of enhancing native biological diversity (e.g. plant and wildlife diversity) and are the logical choice to enhance native pollinators.

A. Native Trees and Shrubs for Pollinator Enhancement

Tree and shrub plantings may be designed for a number of concurrent purposes, such as wildlife enhancement, streambank stabilization, windbreak, and/or pollinator enhancement. These are just some of the tree and shrub species that you might want to consider, paying close attention to overlapping bloom periods and the appropriate plant for the site conditions.

Common Name	Scientific Name	States in which species occurs	Habitat	Flower Color	*Height Mature (feet)	Light Needs	*pH Min.	*pH Max.	Notes
Very Early Blooming Plants									
Pussy willow	*Salix discolor*	ME,VT, NH, MA, CT, RI	wet	grey, green, yellow	40	sun to part shade	4	7	Separate male and female plants; valuable for very early season pollen
Black willow	*Salix nigra*	ME,VT, NH, MA, CT, RI	wet	green, yellow	100	sun	4.8	8	Separate male and female plants; valuable for very early season pollen
Redbud	Cercis canadensis	MA, CT	dry, mesic	pink	15	sun to shade	4.5	7.5	Leaves also used by leafcutter bees
Cherry	*Prunus* spp.	ME,VT, NH, MA, CT, RI	mesic	white, pink	25	sun	5	7	Alternate host for plum curculio and various diseases of other fruit trees; do not plant near orchards

Maple	*Acer* spp.	ME, VT, NH, MA, CT, RI	mesic	green, yellow, red	100	sun to shade	3.7	7.3	Valuable for very early season pollen production
Early Blooming Plants									
Black Chokeberry	*Aronia melanocarpa*	VT, NH, ME, MA, CT, RI	dry, mesic, wet	white	6	sun to shade	6	7.5	Alternate host for plum curculio and various diseases of other fruit trees; do not plant near orchards
Azalea	*Rhododendron* spp.	VT, NH, ME, MA, CT, RI	wet	pink	20	sun to shade	4	5.3	Visited by bumble bees, nectar may be poisonous to honey bees
Hawthorn	*Crataegus* spp.	VT, NH, ME, MA, CT, RI	dry	white	30	sun	4.5	7.2	Alternate host for plum curculio and various diseases of other fruit trees; do not plant near orchards
Early to Mid-Season Blooming Plants									
Basswood	*Tilia americana*	VT, NH, ME, MA, CT, RI	mesic	white	40	share to sun	6.5	8.5	Visited by many bee, wasp, and fly species; important honey plant
False Indigo	*Amorpha fruiticosa*	VT, NH, ME, MA, CT, RI	wet, mesic	purple	18	Sun	5.5	7.5	
Leatherleaf	*Chamaedaphne calyculata*	VT, NH, ME, MA, CT, RI	wet	white	4	sun to partial shade	5	6	
Mid-Season Blooming Plants									
Carolina Rose	*Rosa carolina*	VT, NH, ME, MA, CT, RI	mesic	pink, white	5	sun to part shade	4	7	Good quality flowers, leaves also used by leafcutter bees

Virginia Rose	*Rosa virginiana*	VT, NH, ME, MA, CT, RI	mesic	pink	6	sun to part shade	5	7	Good quality flowers, leaves also used by leafcutter bees
Redosier Dogwood	*Cornus sericea*	VT, NH, ME, MA, CT, RI	wet	white	4	sun to shade	5	7	
New Jersey Tea	*Ceanothus americanus*	VT, NH, ME, MA, CT, RI	dry, mesic	white	3	sun to shade	4.3	6.5	
Buttonbush	*Cephalanthus occidentalis*	VT, NH, ME, MA, CT, RI	wet	white	20	sun to shade	5.3	8.5	
Sourwood	*Oxydendrum arboreum*	RI	wet, mesic	white	35	sun to shade	4	6.5	Good honey bee plant
Late Season Blooming Plants									
Meadowsweet	*Spiraea alba*	VT, NH, ME, MA, CT, RI,	mesic	white	3	sun to part shade	4.3	6.8	

B. Native Forbs (wildlflowers)

There is a vast array of native forbs to choose from in designing a pollinator enhancement. These are species that you might consider using in a hedgerow "bottom" (at the base of one or both sides of a hedgerow), riparian buffer, windbreaks, alley cropping, field border, filter strip, waterway or range planting to enhance conditions for pollinators. These are just some of the plant options that you might want to consider, paying close attention to overlapping bloom periods and the appropriate plant for the site conditions.

Common Name	Scientific Name	States in which species occurs	Habitat	Flower Color	*Height Mature (feet)	Light Needs	*pH Min.	*pH Max.	Annual, Perennial, or Biennial	Notes
Early Blooming Plants										
Wild blue indigo	*Baptisia australis*	NH, VT, MA, CT, RI, MA	mesic, dry	blue	5	sun	5.8	7	P	
Horseflyweed	*Baptisia tinctoria*	VT, NH, ME, MA, RI, CT	mesic, dry	yellow	2.5	sun	5.8	7	P	
Wild lupine	*Lupinus perennis*	VT, NH, ME, MA, CT, RI	mesic, dry	blue	2	sun to part shade	6	7.5	P	Prone to powdery mildew, used as a host plant by some butterflies
Marsh marigold	*Caltha palustris*	VT, NH, ME, MA, RI, CT	wet	yellow	2	sun	4.9	6.8	P	Wetland emergent
Wild geranium	*Geranium maculatum*	VT, NH, ME, MA, RI, CT		purple	2	sun to shade	5.5	8.5	P	
Early to Mid-Season Blooming Plants										
Spiderwort	*Tradescantia virginiana*	VT, NH, ME, MA, RI, CT	mesic, dry	blue	1	sun to part shade	4	8	P	

Wild onion	*Allium* spp.	VT, NH, ME, MA, RI, CT		white, blue, pink	1				B,P	Some species are threatened or special concern in some New England states; other species may be weedy; check PLANTS database for current information
Smooth penstemon	*Penstemon digitalis*	VT, NH, ME, MA, RI, CT	mesic, dry	white	4	sun to part shade	5.5	7	P	Excellent nectar producer, visited by many wild bees, honey bees, hummingbirds, sphynx moths
Hairy beardtongue	*Penstemon hirsutus*	VT, NH, ME, MA, RI, CT							P	
Mid-Season Blooming Plants										
Butterfly Milkweed	*Asclepias tuberosa*	VT, NH, ME, MA, CT, RI	dry	orange	2	sun	4.8	6.8	P	Monarch butterfly host plant, good qualtiy bee flowers
Partridge pea	*Chamaecrista fasciculata*	CT, RI, MA	mesic, dry	yellow	2.5	sun to part shade	5.5	7.5	A	Additional nectaries at the base of leaf petioles
Blue lobelia	*Lobelia siphilitica*	VT, NH, ME, MA, RI, CT	wet	blue	2	sun	5.8	7.8	P	

Cardinal flower	*Lobelia cardinalis*	VT, NH, ME, MA, RI, CT	wet	red	5	sun to part shade	5.8	7.8	P	Primarily hummingbird pollinated, visited by butterflies, nectar robbed by honey bees
Purple coneflower	*Echinacea* spp.	VT, CT, RI, MA, ME	mesic	purple	2	sun	6.5	7.2	P	Visited by many bee and butterfly species; both *E. purpurea* and *E. pallida* found various New England states
Lavender hyssop	*Agastache foeniculum*	RI, CT, NH		white, pink	5	sun to part shade	6	8	P	Excellent nectar plant, visited by honey bees, hummingbirds, bumble bees
Wild bergamot	*Monarda fistulosa*	VT, NH, ME, MA, RI, CT	mesic, dry	pink, blue, red	4.5	sun to part shade	6	8	P	High-value bumble bee plant
Swamp milkweed	*Asclepias incarnata*	VT, NH, ME, MA, RI, CT	wet	red	4.5	sun	5	8	P	Monarch butterfly host plant, good qualtiy bee flowers
Common milkweed	*Asclepias syriaca*	VT, NH, ME, MA, RI, CT	mesic, dry, wet	pink	6.5	sun	5	8	P	Monarch butterfly host plant, good qualtiy bee flowers; may be aggressive
Wild golden glow	*Rudbeckia laciniata*	VT, NH, ME, MA, RI, CT	wet, mesic	yellow	8	sun to shade	4.5	7	P	
Culver's root	*Veronicastrum virginicum*	ME, VT,		white	5	sun to shade	6.5	7.5	P	

		MA, CT								
Dotted mint	*Monarda punctata*	VT, MA, CT	dry, mesic	pink	5.5	sun to part shade	6	7.5	P	
Joe Pye weed	*Eupatorium purpureum*	VT, NH, ME, MA, RI, CT	wet, mesic	purple	6	sun to part shade	6	7.5	P	Visited by bees and butterflies
Virginia mountain mint	*Pycnanthemum virginianum*	VT, NH, ME, MA, RI, CT	mesic	white	3	sun to part shade	6	8	P	
Mid to Late Season Blooming Plants										
Bottle gentian	*Gentiana andrewsii*	VT, NH, MA, RI, CT	mesic	blue	2	sun to part shade	5.8	7.2	P	Pollinated only by bumble bees
New England blazing star	*Liatris scariosa*	CT, RI, ME, NH, MA	mesic	purple	4	sun	6	7.5	P	Threatened and endangered in some New England states; check regulations before planting non-local eco-types
Marsh blazing star	*Liatris spicata*	CT, RI, MA	mesic	purple	5	sun	6	7.5	P	
Common evening primrose	*Oenothera biennis*	VT, NH, ME, MA, RI, CT	mesic	yellow	6	sun	5	7	B	Visited by bees and moths; prone to Japanese beetle and earwig infestations
Northern evening primrose	*Oenothera parviflora*	VT, NH, ME, MA, RI, CT	mesic	yellow	5	sun	5	7	B	Visited by bees and moths; prone to Japanese beetle and earwig infestations
White turtlehead	*Chelone glabra*	VT, NH, ME, MA, CT, RI	wet	white	3	sun to part shade	6	8	P	

Early goldenrod	*Solidago juncea*	VT, NH, ME, MA, RI, CT	mesic, dry	yellow	3	sun to part shade	5.5	7.7	P	
Boneset	*Eupatorium perfoliatum*	VT, NH, ME, MA, RI, CT	wet	white	5	sun	5.5	8	P	
Giant Sunflower	*Helianthus giganteus*	ME, VT, MA, CT, MA	mesic, dry	yellow	5	sun to part shade	6	7.5	P	
Obedient Plant	*Physostegia virginiana*	VT, NH, ME, MA, RI, CT	wet, mesic	pink	4	sun	6	7.5	P	
Late Season Blooming Plants										
Showy goldenrod	*Solidago speciosa*	VT, NH, MA, CT, RI	mesic, dry	yellow	4	sun	5.5	7.5	P	Prone to powdery mildew
Sneezeweed	*Helenium autumnale*	ME, VT, MA, CT, RI, MA	mesic	yellow	5	sun	4	7.5	P	
Gray goldenrod	*Solidago nemoralis*	VT, NH, ME, MA, RI, CT	mesic	yellow	2	sun	6.5	7.5	P	
Licorice-scented goldenrod	*Solidago odora*	MA, CT, RI, NH, VT	mesic	yellow	3	sun	6	7.5	P	
Wrinkleleaf goldenrod	*Solidago rugosa*	VT, NH, ME, MA, RI, CT	mesic	yellow	3	sun to part shade	5	7.5	P	
Smooth blue aster	*Symphyotrichum laeve*	VT, NH, ME, MA,	mesic, dry	blue	4	sun	5.5	7.5	P	Prone to powdery mildew

		CT, RI								
Calico aster	*Symphyotrichum lateriflorum*	VT, NH, ME, MA, RI, CT	mesic	white, red, yellow	4	sun	5.5	7.5	P	
New York aster	*Symphyotrichum novi-belgii*	VT, NH, ME, MA, RI, CT	mesic		4	sun	5.5	7.5	P	
New England aster	*Symphyotrichum novae-angliae*	VT, NH, ME, MA, RI, CT	mesic	purple	4	sun	5.5	7.5	P	Important bumble bee plant, very late blooming
White heath aster	*Symphyotrichum ericoides*	VT, NH, ME, MA, RI, CT	dry	white	4	sun	5.5	7.5	P	Extremely late blooming, often flowers after bees are dormant

C. Native Bunch Grasses

Herbaceous plantings should include at least one native bunch grass or clump-forming sedge adapted to the site in addition to the forbs that will be planted. Including a grass or sedge in the planting mixture will help keep weeds out of the planting area, stabilize the soil, provide overwintering habitat for beneficial insects, forage resources for larval growth stages of some butterflies, and nest sites for bumble bees.

In general warm season bunch grasses (which produce most of their leaf mass in the summer) are more favorable than cool season grasses that grow quickly in the spring, and thus potentially shade out developing forbs. Anecdotal evidence also suggests that tall grasses crowd out forbs more easily than short grasses. Seeding rates for grasses should also not exceed seeding rates for forbs.

Common Name	Scientific Name	States in which species occurs	*Height Mature (feet)	Light Needs	*pH Min.	*pH Max.	Notes
Little Bluestem	*Schizachyrium scoparium*	VT, NH, ME, MA,	3	sun	5	8.4	Provides bumble bee nest habitat

		CT, RI					
Indiangrass	*Sorghastrum nutans*	VT, NH, ME, MA, CT, RI	6	sun	4.8	8	Provides bumble bee nest habitat
Sideoats Grama	*Bouteloua curtipendula*	CT, ME	3	sun	5.5	8.5	Provides bumble bee nest habitat
Purple Lovegrass	*Eragrostis spectabilis*	VT, NH, ME, MA, CT, RI	1	sun	4	7.5	Provides bumble bee nest habitat

II. Non-Native Plant Species for Cover Crops, Green Manures, Livestock Forage and Insectary Plantings

A number of non-native plants used for cover crops, insectaries, green manures, or short-term plantings are productive forage sources for pollinators. Some of these species could become weedy (e.g. able to reproduce and spread) so you will want to choose appropriate species for your needs and monitor their development on your site.

Insectary plantings may be placed as a block inside of a crop, along the borders or just outside of a crop to attract beneficial insects to the crop for biological control (i.e. predators or parasitoids) of crop pests. Beneficial insects can be significantly more abundant in insectary plantings than where such habitat is absent. Some of these plants can also provide good pollen or nectar sources for bees. These may be annual plantings or more permanent plantings along the outer rows within the field or outside but adjacent to the crop field. The principles of enhancement for pollinators also generally apply to insectary plantings - such as including a diversity of flowers that bloom through the entire growing season to provide a steady supply of nectar.

Common Name	Scientific Name	Flower Color	*Height Mature (feet)	Light Needs	*pH Min.	*pH Max.	Annual, Perennial, or Biennial	Notes
Early Blooming Plants								
Borage	*Borage officinalis*	blue	1.5	sun	6	7.5	A	Excellent honey plant
Crimson clover	*Trifolium incarnatum*	red	1.5	sun	5.5	7.5	A	
Hairy vetch	*Vicia villosa*	purple	1.5	sun	6	7.5	A	
Early to Mid-Season Blooming Plants								
Purple vetch	*Vicia atropurpurea*	purple	1	sun	5.5	6.5	A	
Daikon radish	*Raphanus sativus*	white, purple	2	sun	6.5	7.5	B	Must be planted in spring to ensure flowering the same year
Mid-Season Blooming Plants								
Alfalfa	*Medicago*	blue	2	sun	6	8.5	P	Good

	sativa							honey plant
Mustard	*Brassica* spp.	yellow	4	sun	6	7.2	A	
White clover	*Trifolium repens*	white	0.5	sun	6	7.5	P	Excellent honey plant
Sweet White Clover	*Melilotus alba*	yellow	5	sun	5	8	A	Excellent honey plant
Red clover	*Trifolium repens*	red	0.5	sun	6	7.5	P	Supports long-tongued bumble bee species
Mid to Late Season Blooming Plants								
Buckwheat	*Fagopyrum esculentum*	white	2	sun	6	8.5	A	Good honey plant

III. Garden Plants

This type of planting will generally be a more permanent planting outside but adjacent to cropland. The pollinator habitat enhancement principles will also apply—such as including a diversity of flowers that bloom through the entire growing season to provide a steady supply of nectar and pollen. Also, when selecting plant varieties, keep in mind that the simple-flowered cultivars generally provide greater nectar and pollen rewards than multi-petaled (e.g. double petal) varieties.

The plants suggested below are all commonly available garden plants. These species will generally do best in a full sun location and may require supplemental irrigation and fertilization. Establishment of perennial plants may take a few years, but they will often last for an extended period of time. One strategy is to plant annual and perennial garden plants together, with the annual plants providing immediate benefits the first year, while the perennial plants become established.

Common Name	Scientific Name	Flower Color	*Height Mature (feet)	Light Needs	*pH Min.	*pH Max.	Annual, Perennial, or Biennial	Notes
Early Blooming Plants								
Siberian Squill	*Scilla siberica*	blue	0.5	part sun to full shade	5.5	8	P	Naturalizes easily
Japanese pieris	*Pieris japonica*	white	12	shade	4.2	5.5	P	Visited by many early spring bee species
Borage	*Borago officinalis*	blue	1	sun	6	7.5	A	Valuable honey plant
Apple	*Malus* spp.	pink, white, red	15	sun	5.5	7.5	P	
Mid-Season Blooming Plants								
Lavender	*Lavandula* spp.	purple	3	sun	6.5	7.5	P	
Oregano	*Origanum* spp.	pink	1	sun	6.5	8	P	
Rosemary	*Rosmarinus officinalis*	blue	5	sun	5.5	7.5	P	
Thyme	*Thymus* spp.	pink	1	sun	6.5	8	P	
Basil	*Ocimum* spp.	white	2	sun	4	8	A	

Catmint	*Nepeta* spp.	white, blue	2	sun to part shade	5	8	A, P	Thrives in distrubed sites
Mint	*Mentha* spp.	white, pink	2	sun to part shade	5	7	P	
Sea holly	*Eryngium* spp.	blue	3	sun	6.5	8	P	
Anise hyssop	*Agastache rupestris*	purple	4	sun to part shade	6	8	P	
Mid to Late Season Blooming Plants								
Common sunflower	*Helianthus annuus*	yellow, orange	9	sun	5.5	7.8	A	
Cosmos	*Cosmos bipinnatus*	white, pink, red	5	sun	6.5	8.5	A	
Russian sage	*Perovskia atriplicifolia*	blue	5	sun	6.5	8	P	
Mexican sunflower	*Tithonia rotundifolia*	orange	6	sun	6	8	A	

Bees of New England*

The following table outlines all known bee genera found in New England. Individual life history details for certain species may vary from the general genus-level characteristics described here.

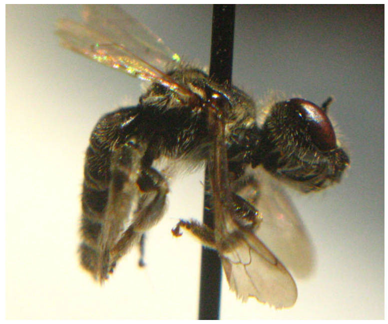
Family	Genus	Nest Site	Sociality	Time of Year	Abundance	Common Name & Notes
Andrenidae	*Andrena*	Ground	Solitary & Communal	All season	Abundant	Mining bees: among the most common North American genera, very common in spring.
	Calliopsis	Ground	Solitary	Summer	Local	Mining bees.
	Perdita	Ground	Solitary & Communal	Summer	Local	Mining bees.
	Protandrena	Ground	Solitary	Summer	Local	Mining bees.
Apidae	*Anthophora*	Wood & Ground	Solitary	Spring & Summer	Local	Mining bees. Males sometimes form "sleeping aggregations," clustering together on a plant stem.
	Apis	Hives	Social	All season	Abundant	Honey bees.
	Bombus	Rodent burrows, large cavities	Social	All season	Abundant	Bumble bees.
	Ceratina	Stems	Solitary	All season	Abundant	Small carpenter bees.
	Epeoloides	Parasite	N/A	Summer	Extremely rare	Cuckoo bee. Eggs lain in the nests of other bees.
	Epeolus	Parasite	N/A	Summer & Fall	Local	Cuckoo bee. Eggs lain in the nests of other bees.
	Holcopasites	Parasite	N/A	Summer	Uncommon	Cuckoo bee. Eggs laind in the nests of other bees.
	Melissodes	Ground	Solitary	Summer & Fall	Common	Long-horned bees: often associated with sunflowers and related species.
	Nomada	Parasite	N/A	All season	Abundant	All species cuckoo bees, laying their eggs in the nests of other species. Usually black and yellow, hairless and wasp-like in appearance.
	Peoponapis	Ground	Solitary	Summer	Local	Squash bees, usually found nesting at the base of cucurbit plant species. Males may rest overnight in squash flowers.
	Svastra	Ground	Solitary	Summer	Rare	Sunflower bees, usually associated with Asteraceae species.
	Triepeolus	Parasite	N/A	Summer & Fall	Local	Cuckoo bee. Eggs lain in the nests of other bees.
	Xylocopa	Wood	Nest sharing	All season	Common	Large carpenter bees: often resemble bumble bees in size and color, but are typically shinier and have less hair.
Colletidae	*Colletes*	Ground	Solitary	All season	Common	Polyester bees: nests are lined with a waterproof cellophane-like glandular secretion.
	Hylaeus	Stems & Ground	Solitary	Summer	Common	Yellow-faced bees: Typically very small, wasp-like in appearance.
Halictidae	*Agapostemon*	Ground	Communal & Solitary	All season	Common	Green sweat bees: usually metallic green in color.

	Augochlora	Wood	Solitary	Summer	Common	Sweat bees: so named for their occasional attraction to perspiration.
	Augochlorella	Ground	Social	All season	Common	Sweat bees.
	Augochloropsis	Ground	Nest sharing	Summer	Local	Sweat bees.
	Dufourea	Ground	Solitary	Summer	Local	Sweat bees.
	Halictus	Ground	Social & Solitary	All summer	Abundant	Sweat bees. Unlike other bees, Halictus may be regularly found foraging at twilight. May nest as solitary individuals, or complex xolonies with multiple queens and hundreds of workers.
	Lasioglossum	Ground & Wood	Communal & Social	All season	Abundant	Sweat bees: One of the largest and most common genera, often overlooked due to their small size.
	Sphecodes	Parasite	N/A	All season	Abundant	Cuckoo bee. Eggs lain in the nests of other bees.
Megachilidae	*Anthidiellum*	Masonry	Solitary	Summer	Rare	Leafcutter, resin, and mason bees: Plant saps and resins are collected to seal off nest entrances.
	Anthidium	Wood & Stone Cavities	Solitary	Summer	Common	Carder bees. These species use their mandibles to comb cottony down from hairy leaves, using this material to line their nests.
	Chelostoma	Wood & Stone Cavities	Solitary	Summer	Common	Leafcutter, resin, and mason bees.
	Coelioxys	Parasite	N/A	Summer	Common	Cuckoo bee. Eggs lain in the nests of other bees.
	Dianthidium	Masonry	Solitary	Summer	Rare	Leafcutter, resin, and mason bees.
	Heriades	Wood & Stone Cavities	Solitary	Summer	Uncommon	Leafcutter, resin, and mason bees.
	Hoplitis	Wood, Stone Cavities, Masonry	Solitary	Summer	Local	Mason bees.
	Megachile	Wood, Ground, & Stone Cavities	Solitary	Summer	Local	Leafcutter bees. Some species clip circular leaf sections to line their nests, and to seal off nest entrances.
	Osmia	Wood & Stone Cavities	Solitary	Spring & Summer	Abundant	Leafcutter and mason bees. Nest entrances closed with mud or masticated leaf pieces.
	Paranthidium	Ground	Solitary	Summer	Rare	Leafcutter, resin, and mason bees.
	Stelis	Parasite	N/A	Summer	Uncommon	Cuckoo bee. Eggs lain in the nests of other bees.
Melittidae	*Macropis*	Ground	Solitary	Summer	Rare	Oil collecting bees. These very rare bees collect floral oils which is mixed with pollen and feed to larvae.

*(Adapted from The Bee Genera of Eastern Canada by Laurence Packer, Julio Genaro, and Cory Sheffield. Canadian Journal of Arthropod Identification. No. 3. 2007, and the Great Sunflower Project, Gretchen LaBuhn. 2008. http://www.greatsunflower.org)

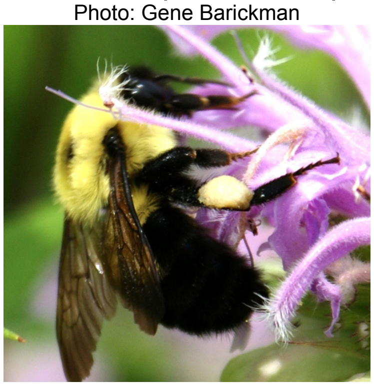
***Andrena* (mining bee)**
Photo: Eric Mader

Calliopsis
Photo: Eric Mader



***Apis (*honey bee)**
Photo: Toby Alexander

***Bombus* (bumble bee)**
Photo: Gene Barickman



Ceratina
Photo: Eric Mader

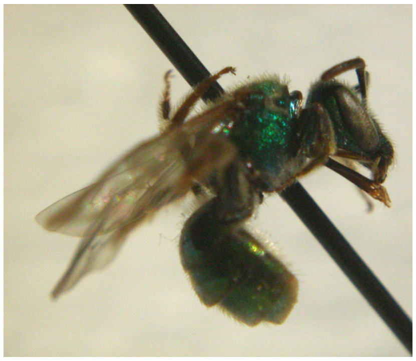
***Melissodes* (long-horn bee)**
Photo: Mace Vaughan

***Nomada* (cuckoo bee)**
Photo: Eric Mader

***Xylocopa* (large carpenter bee)**
Photo: Gene Barickman

***Agapostemon* (green sweat bee)**
Photo: Eric Mader

***Augochlorella* (sweat bee)**
Photo: Eric Mader

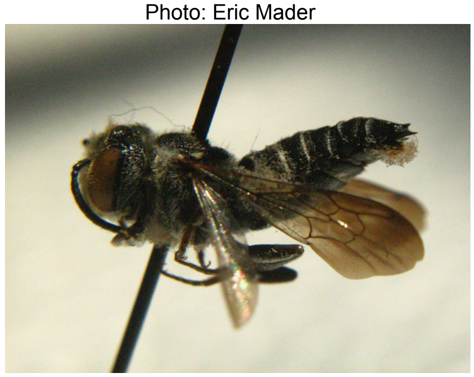


***Halictus* (sweat bee)**
Photo: Mace Vaughan

***Lasioglossum* (sweat bee)**
Photo: Eric Mader

***Anthidium* (carder bee)**
Photo: Eric Mader

***Coelioxys* (cuckoo bee)**
Photo: Eric Mader



***Hoplitis* (mason bee)**
Photo: Eric Mader

***Megachile* (leafcutter bee)**
Photo: Eric Mader

***Osmia* (mason bee)**
Photo: Connie Stubbs

Appendix: Additional Information

In addition to this document, information on pollinator habitat conservation is available through a number of other publications, websites, and organizations.

I. Regional Technical Support

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Conservation and Management of Native Bees in Cranberry
This comprehensive study of native bee visitors to cranberry in Maine and Massachusetts includes extensive lists of native plants that provide alternative forage sources for bees in northeastern agricultural settings.
www.umaine.edu/mafes/elec_pubs/techbulletins/tb191.pdf

University of Maine Extension Wild Blueberry Fact Sheets
UMaine's blueberry website includes a number of fact sheets on native bee conservation and management. Common local pollinators of blueberry are described.
http://wildblueberries.maine.edu/factsheets.html#bees

II. Publications

Black, S.H., N. Hodges, M. Vaughan and M. Shepherd. 2008. Pollinators in Natural Areas: A Primer on Habitat Management http://www.xerces.org/pubs_merch/Managing_Habitat_for_Pollinators.htm

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USDA-NRCS. Conservation Security Program Job Sheet: *Nectar Corridors*, Plant Management EPL 41. *www.wv.nrcs.usda.gov/programs/csp/06csp/JobSheets/nectarCorridorsEL41.pdf*

USDA, NRCS, Idaho Plant Material Technical Note #2: *Plants for Pollinators in the Intermountain West*. ftp://ftp-fc.sc.egov.usda.gov/ID/programs/technotes/pollinators07.pdf

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See "Native Pollinators", "Butterflies", "Bats", "Ruby-throated Hummingbird" and "Early Successional Habitat" Fish and Wildlife Habitat Management Leaflet Numbers 34, 15, 5, 14 and 41 respectively. http://www.whmi.nrcs.usda.gov/technical/leaflet.htm

III. Web-Sites

1. POLLINATOR INFORMATION

- The Xerces Society Pollinator Conservation Program http://www.xerces.org/Pollinator_Insect_Conservation
- USDA ARS Logan Bee Lab www.loganbeelab.usu.edu
- Logan Bee Lab – list of plants attractive to native bees http://www.ars.usda.gov/Main/docs.htm?docid=12052
- The Pollinator partnership http://www.pollinator.org/
- U.S. Forest Service Pollinator Information http://www.fs.fed.us/wildflowers/pollinators/index.shtml
- U.S. Fish & Wildlife Service Information http://www.fws.gov/pollinators/Index.html
- Pollinator friendly practices http://www.nappc.org/PollinatorFriendlyPractices.pdf
- Urban bee gardens http://nature.berkeley.edu/urbanbeegardens/index.html

2. HABITAT RESTORATION WITH NATIVE PLANTS

- Considerations in choosing native plant materials http://www.fs.fed.us/wildflowers/nativeplantmaterials/index.shtml
- Selecting Native Plant Materials for Restoration http://extension.oregonstate.edu/catalog/pdf/em/em8885-e.pdf
- Native Seed Network http://www.nativeseednetwork.org/ has good species lists by ecological region and plant communities
- Prairie Plains Resource Institute has extensive guidelines for native plant establishment using agricultural field implements and methods http://www.prairieplains.org/restoration_.htm

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Pollinator Conservation Program

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