NRCS

Delaware Department of Agriculture

Serving Agriculture and Protecting Consumers

Farm Management for Native Bees

A Guide for Delaware

What are Native Bees?

The European honey bee, despite its long history as a managed pollinator of crop plants in the United States, is not native to North America. The term "native bee" refers to any of a large and very diverse group of wild bees that are important pollinators of wild and cultivated plants. North America is home to some 4,000 species of wild bees, around 200 of which have been found in Delaware. Based on higher totals recorded in adjacent states, it is likely that many more species will be recorded in Delaware in coming years.

There are many different groups of native bees that pollinate crop plants, including bumble bees, squash bees, mason bees, long-horned bees and sweat bees, among others. Because most native bees are solitary, nesting individually, rather than in large colonies, they are often less conspicuous than honey bees. However, some solitary bees form large, conspicuous aggregations in preferred nesting sites. More than two-thirds of the native bee species in North America nest in the ground, while most of the remaining species hollow out the pith of twigs and brambles, or nest in preexisting cavities such as the tunnels created in dead logs and snags by wood-boring beetles. Bumble bees, social bees that contribute to pollination of many crops, nest in hives built in grass tussocks and old rodent nests. For more information on native bee biology, including how to recognize the groups of native bees, consult the the references listed at the end of this booklet.

Most farms in Delaware already benefit from native bee pollination, but there are many ways to help build the populations of native bees on your farm. This guide presents some basic concepts to help you protect and grow your populations of wild bees.

In addition to honey bees (top), native sweat bees (middle) and bumble bees (bottom) are important crop pollinators.

A Few Types of Native Bees:

Bumble bees

Genus *Bombus*

These large, hairy, black and yellow bees are common flower visitors. Like honey bees, bumble bees are social and live in hives, but unlike honey bees, the workers die in the fall, leaving only a mated queen to found a new colony the next spring. Bumble bees are generalist pollen foragers and excellent pollinators of a variety of crops.

Sweat bees

Family Halictidae

This is a large and diverse family of bees that includes many excellent crop pollinators. They are often brown or black, occasionally with gray stripes, but some are metallic green or blue (see the photo on page one).

Mining bees

Family Andrenidae

A large family with many species that are difficult to tell apart. Most are early spring flyers that pollinate orchard fruit trees and many wild trees, shrubs, and early wildflowers. Some species fly later in the season and pollinate other crops.

Leaf-cutter bees

Family Megachilidae

Many of these bees nest in wood, and some (*Osmia, Megachile*) are very important crop pollinators. Members of the genus *Osmia*, known as mason bees, are among the most important pollinators of apples.

Long-horned bees

Tribe Eucerini

These are important ground-nesting crop pollinators. *Melissodes* and *Peponapis* are especially valuable for squash and other cucurbits.

Carpenter bees

Subfamily Xylocopinae

This group includes *Xylocopa virginica*, a large bee that looks much like a bumble bee, but with a hairless abdomen, and *Ceratina*, small, blackish bees with few hairs, that are good crop pollinators.

Why Conserve Native Bees?

Over 100 crop species in North America require insect pollination to be most productive. Populations of managed honey bees have declined in recent years due to mites and diseases. While honey bees are still very important pollinators, encouraging populations of native bees can provide "pollination insurance" during times when honey bees are not available. At the same time, native bees can increase yields for many crops.

If you grow fruits or vegetables you may benefit greatly from native bee pollination. Recent studies in New Jersey and Pennsylvania have shown that native bees alone provide sufficient pollination for most watermelon farms. Native bees are extremely efficient pollinators of pumpkins, tomatoes, apples, berries, and many other crops. Even some varieties of soybeans achieve greater yields with native bees.

If you enhance habitat for bees and other pollinators on the farm, you could even consider marketing your products as "pollinator-friendly." For farms that already offer roadside markets, pick-your-own, or farm tours, pollinator conservation can add to the tourism value of your property. With the growing demand for native plants for use in conservation projects, there is even potential for developing a side business of selling native plant seed or stock. The natives you grow would then help support healthy populations of the bees that pollinate your other crops.

Even if you don't grow any crops that need bee pollination, there are other advantages to improving bee habitat on the farm. Native bees provide essential pollination services to native trees and wildflowers, which provide habitat for other beneficial animals. Birds, predaceous beetles, parasitic wasps, and other natural enemies of crop pests find food and refuge in hedgerows, field borders, and other areas of diverse native vegetation. Several studies have shown that unsprayed field borders planted in a diverse mix of native wildflowers harbor more birds and beneficial insects than conventionally-managed borders.

Field borders, hedgerows, filter strips, and other conservation practices can also help conserve water and reduce erosion and fertilizer runoff. If you live on your farm, you can plant shelterbelts, orchards, meadows, and flowerbeds around your home to provide bee habitat while enhancing the appeal and protection of your farmstead.

Why Conserve Native Bees?

Value of native bees to agriculture

Native bees pollinated approximately $3 billion of crops in the U.S. during the year 2000.

When honey bees are in short supply, native bees can act as an insurance policy when habitat is present.

Native bees compared to honey bees

Native bees pollinate apples, cherries, squash, watermelon, blueberries, cranberries, and tomatoes far more effectively than honey bees on a bee-per-bee basis.

Many native bee species forage earlier or later in the day than honey bees.

Native bees will often visit flowers in wet or cold conditions when honey bees remain in the hive.

How native bees benefit crops

If enough natural habitat is close by, native bees can provide all of the pollination necessary for many crops.

Bumble bees, long-horned bees, and sweat bees are all common visitors to watermelon flowers in Delaware. Forty-six species of native bees have been observed visiting watermelon flowers in New Jersey.

Over eighty species of bees have been recorded pollinating berry crops in Maine and Massachusetts, while sixty-seven species visit blueberries in Nova Scotia.

Native pollinators have been shown to nearly triple the production of cherry tomatoes in California.

Delaware squash and pumpkin crops are heavily visited by native squash bees and bumble bees.

Apples (upper right), tomatoes (lower right), and watermelons (upper left) are pollinated by native bees. The squash bee, Peponapis pruinosa (lower left) is the most important native bee on pumpkin and squash.

Why Conserve Native Bees?

Some Common Crops pollinated by native bees

Apple
Blackberry
Blueberry
Canola (seed)
Cantaloupe
Cherry
Clover (seed)
Cranberry
Cucumber
Eggplant
Lima bean
Peach
Pepper
Pumpkin
Raspberry
Soybean (some varieties)
Squash
Strawberry
Sunflower (seed)
Tomato
Watermelon (shown)

How Do I Begin?

The following three steps will help you get started. Steps 1 and 2 require planning and some changes to everyday practices, while Step 3 requires more investment of time and resources.

1. PRESERVE the bee habitat you already have on the farm. The first step is *recognizing* the places on your property that bees use for feeding, nesting, and overwintering. You can then learn how to maintain and enhance those sites.

2. PROTECT bees from pesticide poisoning, tilling of their nesting sites, mowing of floral resources, and other detrimental activities. The simplest way to accomplish this is to *think about the impact of your farming practices on native bees.*

3. PROVIDE bees with additional resources, including *forage plantings, conservation set-asides, and nest sites.*

Preserve

If your farm is near areas of natural habitat, you may already have strong populations of native bees nearby that visit your crops. The first step in bee conservation is to recognize important areas of habitat that already exist on your farm.

Recognizing Bee Habitat

The following areas around the farm provide habitat for pollinators. These areas should be kept untilled and are excellent locations to start improving your bee habitat:

Field borders
Woodlots
Ditch banks
Stream edges
Hedgerows
Utility line easements
Land around garages and barns
Farmstead yards and gardens
Existing conservation areas
Roadsides
Wetlands
Pond edges
South facing soil embankments

Field margins are ideal locations to establish bee plantings.

Since many bees nest in the ground, any well-drained, untilled area represents potential nesting habitat. If you are able to locate bee nest aggregations on your farm, these areas should be left untilled and can serve as focal areas for further habitat enhancement. Bees need a variety of wild flowers for pollen and nectar, so weedy areas, conservation set-asides, or other areas of undisturbed vegetation are good areas to focus on. Woodlots and shrubby margins contain valuable floral resources, nesting sites, and shelter.

Pollinator habitat is not limited to upland sites. Wetlands, ponds, streams, and ditches provide valuable resources for native bees. Some species, such as mason bees, need a source of clean, pesticide-free mud to build nests. Hollow-stemmed wetland plants like joe-pye weed and elderberry provide nest sites for stem-nesting bees. The diverse community of native wetland plants often found in these areas is also an excellent source of nectar and pollen. Unmowed buffer strips around wetland edges, ditches, and farm ponds will help support native bees that pollinate crops in nearby fields.

Insecticide spraying, mowing of field margins and blooming crops, tilling of fields and field borders, logging, firewood removal, brush clearing, and spraying weeds with herbicides are all common practices that can kill bees and destroy the resources they need to survive. Whenever you undertake one of these activities, keep in mind the potential impact of your actions on native bees.

Native Bees and Pesticides

Insecticides:

Nearly all broad-spectrum insecticides are toxic to both honey bees and native bees. In order to protect bees and maximize pollination, insecticide use should be kept to a minimum. Various Integrated Pest Management (IPM) strategies can be used to help reduce the need for chemical sprays. For more information on IPM practices for a particular crop, contact your local extension agency.

When you must spray insecticides, the following guidelines will help limit damage to bee populations:

1. Never spray insecticides on a crop that is in bloom, or on blooming wildflowers, weeds, or cover crops.

2. Spray in the evening, preferably an hour after sunset, when native bees have stopped foraging for the day. Many native bees are active before dawn; morning and afternoon sprays are much more likely to poison bees directly. Also, spray when there will be no dew (the water keeps the insecticide active longer).

3. Always use the least toxic insecticide available. Resources are available to help you determine which insecticides are safer for bees. See the reference section at the end of this booklet.

4. To avoid insecticide drift, spray from the ground, rather than from an aircraft. Use a low boom when possible.

5. Whenever practical, leave an unsprayed crop buffer at field margins (ideally 25 ft.) to minimize drift onto hedgerows, wildflowers, and bee nesting areas.

6. If you use a center-pivot system to deliver insecticides to a crop, avoid using an end gun or swing arm corner watering attachment. This will result in slightly less irrigated acreage, but will reduce variation in the rate of chemical applied throughout the field, and will also provide a buffer area in the field corners that can be planted in perennial drought-tolerant bee forage plants. The resulting field corners will act as bee sanctuaries.

7. No matter how you deliver insecticides, check your systems regularly for leaks and mechanical problems.

Herbicides:

While most herbicides are relatively non-toxic to bees, they can harm bee populations by wiping out "weeds" that provide pollen and nectar. Many beneficial native plant species are widely regarded as "weeds," even when they pose little or no threat to invade crop fields. Knowing which plants are truly problematic and which are not is an important step in managing your farm for native bee diversity. Always strive to eliminate plants that are both non-native and highly invasive, as well as those that are causing major problems in crops. Remember, though, that many wild plants that may seem "weedy" are important to the bees on your farm.

While it is best to use native perennials in plantings for bee forage, many non-native and minimally invasive species already present in lawns and fields are excellent sources of pollen and nectar, especially early in the growing season. If these non-native plants are growing in places where they don't cause problems by competing with crops, there's no real need to eliminate

Non-native, non-invasive plants that are valuable to bees:

Chicory	*Cichorium intybus*
Cinquefoil	*Potentilla* sp.
Clovers	*Trifolium* sp.
Dandelion	*Taraxacum officinale*
Hawkweed	*Hieracium* sp.
Henbit	*Lamium* sp.
Mustards	*Brassica* sp.
Ox-eye Daisy	*Chrysanthemum leucanthemum*
Queen Anne's Lace	*Daucus carota*
Sweet Clover	*Melilotus* sp.
Yarrow	*Achillea millefolium*

Protect

Steps To Reduce Herbicide Damage to Bee Habitat:

1. Spend time scouting crops for weed problems and find solutions to address specific weeds without extensive spraying (spot spraying, cultural methods).

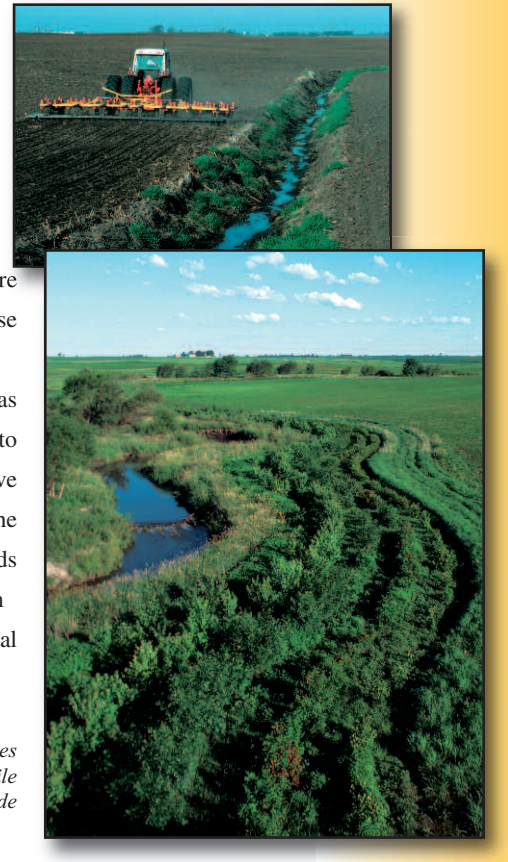
2. Establish no-spray bee forage areas on field borders or set-asides where herbicides are not used, or are used only for spot-spraying of invasive species.

3. Apply herbicides to problem weeds using low-volume sprays when possible in order to minimize drift.

4. For some difficult weeds, such as thistles and knapweed, the plants may be effectively treated during the fall or winter, during which time bees are not actively relying on the blossoms for food.

Native Bees and Tillage

Approximately 70% of all bee species in North America nest in burrows dug into the soil. Tilling destroys these nest tunnels, and results in drastic reductions in soil-nesting bee populations. Therefore, it is important to provide untilled areas on the farm where ground-nesting bees can dig their nests, raise their young, and safely overwinter. To maximize bee visits to crops, untilled areas should be established in close proximity to crop fields, and should be near areas of native plants that provide nectar and pollen. The edges of fields, roads, ditches, and wetlands can be left untilled, and any larger long-term fallow or marginal areas will provide additional undisturbed soil for bee nesting.



Tillage to the edge of a stream or ditch (top) leaves no buffer for bee nesting or foraging habitat, while untilled riparian buffer plantings (bottom) provide nesting habitat and food sources.

Protect

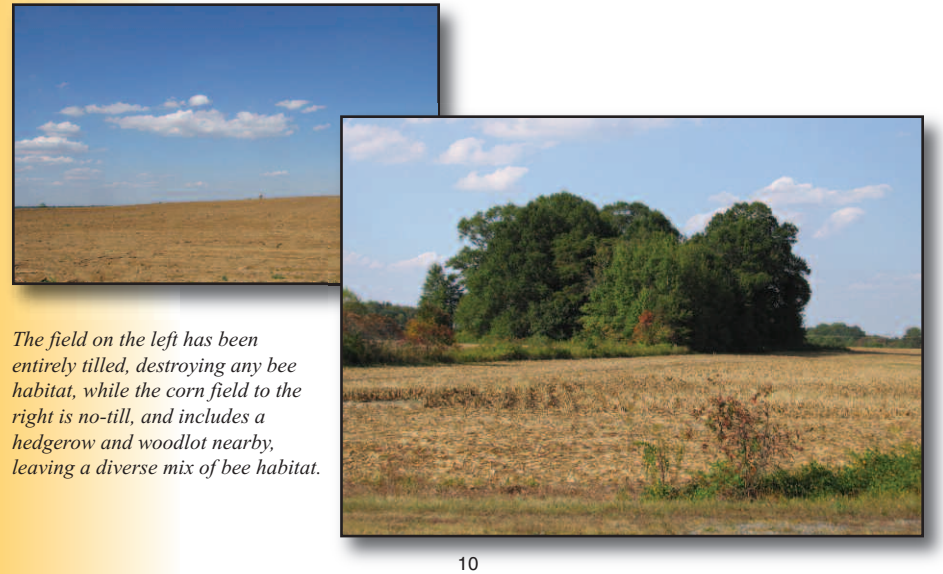
No-till Cropping Systems

The popularity of no-till cropping systems has increased dramatically over the past two decades. As of 2004, no-till systems accounted for 22.6% of planted crops in the U.S., up from only 6.0% in 1990. In Delaware, corn and soybeans are the crops most often grown in no-till systems, but vegetable crops can also realize increased yields and fewer pests with no-till. No-till can save labor, fuel, and time while minimizing soil compaction, pollution, and erosion. In addition, the relatively undisturbed soils and remaining crop residues in these fields harbor more beneficial insects (especially ground-dwelling predators) than conventionally-tilled fields.

Since many native bee species nest in burrows in the soil, no-till systems have great potential for reducing damage to bee populations. Turning over the soil destroys all bee nests down to the depth of tillage, and makes it more difficult for the bees in deeper nests to emerge. In prime areas, soil-nesting bee aggregations can contain thousands of bees. Studies of pumpkin and squash fields have shown that no-till fields can contain three times more pollinating squash bees than conventionally tilled fields.

One potential drawback of current no-till systems is that they depend on seasonal herbicide applications for weed control. While most of the commonly used herbicides (including glyphosate) show little or no toxicity to bees, a few have shown some toxic effects in laboratory studies. More importantly, care should be taken during herbicide application to avoid drift onto field borders and hedgerows, where wildflowers that provide bee forage might be affected.

For more information on no-till cropping systems, contact your county cooperative extension office.



The field on the left has been entirely tilled, destroying any bee habitat, while the corn field to the right is no-till, and includes a hedgerow and woodlot nearby, leaving a diverse mix of bee habitat.

Protect

Native Bees and Crops

Flowering cover crops can serve as important forage for bees. Clovers, including alsike, red, and crimson, as well as sweet clovers, provide food for bumble bees and a wide variety of other native bees. Alfalfa, buckwheat, canola and partridge pea are other useful cover crops for pollinators. In addition to providing weed suppression and soil cover in fields, cover crops can also be used beneath fruit trees in orchards, as intercropping with vegetables, and as alternatives to grass in open areas like lawns or even farm roads.

Ideally, the best plants for cover crops will grow with a low stature and have abundant flowers. These cover crops can also provide several other benefits, such as erosion control, improved soil permeability, nitrogen fixation, and habitat for other beneficial insects. Consult with your cooperative extension offices and county conservation district regarding cover crops best suited to a particular crop or site.

In addition to cover crops, many common field crops can provide a source of nectar and pollen for native bees. Even crops that are not typically grown for their flowers or seeds can support bees if they are allowed to flower before tilling or mowing.

Native Bees and Clearing

Trees act as a windbreak, making it easier for bees to visit flowers and to stay warm on cooler days. Some species of early-blooming trees (including maples, willows, dogwoods, hawthorns and cherries) are excellent sources of nectar and pollen. Dead wood, including standing and fallen dead trees and logs, creates nesting and overwintering sites for many native bee species. Shrublands, bramble patches, and other brushy areas provide additional feeding and nesting opportunities. Consider the needs of native bees before cutting firewood, clearing brush, or logging woodlots. It is best to maintain as much plant species diversity as possible within wooded areas.

In all marginal areas of your farm, try not to be too "tidy" by mowing, spraying, or cutting the trees, shrubs, and wildflowers that bees need to survive.

Flowering cover crops such as Buckwheat (top) are good food sources, while woodlots (middle) provide nest sites for wood-nesting bees (bottom).

Provide

To increase populations of native bees on the farm, you should provide undisturbed areas for nesting and overwintering, as well as a variety of flowering plants that provide pollen and nectar.

Plantings for Bees

One of the most important things you can do to support native bee populations on the farm is to plant and maintain areas of flowering plants that the bees can use to gather nectar and pollen. Here are several important guidelines to follow when planning a forage area:

1. Timing: Choose a variety of plants that bloom at different times of the year, so that pollinators have access to a source of food from early in the spring to late in the fall.

2. Go Native: Select native plants whenever possible, and definitely avoid invasive alien species.

3. Diversity: Choose plants with a variety of floral shapes and colors to appeal to different species of both short-tongued and long-tongued bees.

4. Seeding Rate: If you plant a mix of wildflowers and warm-season grasses, don't seed the grasses too heavily, or the wildflowers will be outcompeted within a few years.

5. Size: While even small plantings are beneficial, larger areas of forage habitat will support larger populations of native bees.

6. Proximity: Plantings should ideally be near nesting habitat and crops requiring insect pollination.

In addition to supporting native bee populations, these plantings can also provide food for natural enemies of crop pests (such as predatory bugs and beetles, parasitic wasps, etc.). For more information on what plants to use for bee forage in Delaware, see the companion booklet to this guide, *Delaware Native Plants for Native Bees.*

Nest Sites for Bees

In addition to providing untilled areas and leaving snags and logs for bee nesting sites, there are several things you can do to enhance bee nesting habitat. **For ground-nesting bees, you can try the following steps to provide nest sites:**

Bare ground. Clear the vegetation from small patches of level or sloping ground and gently compact the soil surface. These bare patches can be from a few inches to a few feet across, and should be well-drained, and in an open, sunny place. A south-facing slope can be a good location. Different ground conditions, from vertical banks to flat ground, will draw different bee species, so create nesting patches in different areas to maximize bee diversity.

Sand pits and piles. In a sunny, well-drained spot, dig a pit about 2' deep, and fill it with a mixture of pale-colored, fine-grained sand and loam. Where soils do not drain well, make piles of the sand/loam mixture instead.

For wood and twig-nesting species, you can build nest blocks (see the following page) or try some of the following approaches:

Logs and snags. Get some logs or old stumps and place them in sunny areas. Those with beetle tunnels are ideal. Plant a few upright, like dead trees. On the southeast side of each log, drill a range of holes, of the same sizes as described below for nest blocks.

Stem or tube bundles. Some plants, like teasel and reeds (*Phragmites*), have naturally hollow stems. Cut the stems into 6" to 8" lengths. Be careful to cut the stems close to a stem node to create a tube with one end closed. Fifteen to twenty stem pieces tied into a bundle (with the closed ends of the stems together) makes a fine nest. You can make a roof to shelter the bundle, or build a wooden frame to hold as many stems as you like. Orient the stems horizontally or slightly downward so they stay dry.

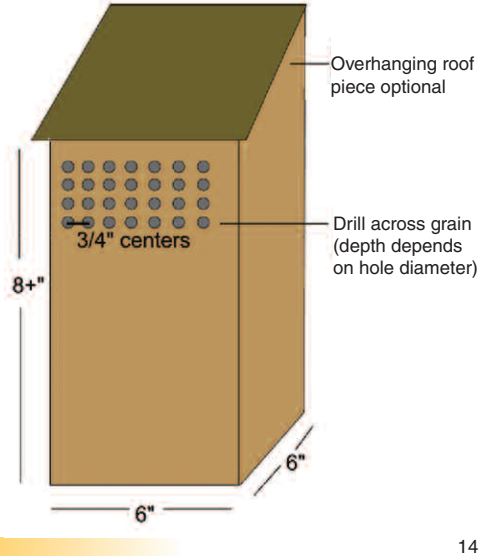
Building Bee Nesting Blocks

In addition to natural habitat features, artificial nest sites are beneficial to cavity-nesting native bees. Placing wooden nesting blocks in blueberry fields in Maine more than doubled the abundance of cavity-nesting *Osmia* bees, the primary native pollinator of blueberry. Nesting blocks will help build the populations of other important cavity-nesting crop pollinators as well.

Bee blocks can be made by drilling nesting holes between 3/32" and 3/8" in diameter, at approximate 3/4" centers, into the side of a block of preservative-free lumber. The holes should be smooth inside, and closed at one end. Drilling across the grain, rather than with the grain, will help produce smoother interiors. 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 to 4" deep. Holes 1/4" or larger should be more than 5" deep. Holes may be lined with cardboard straws or paraffin-coated paper straws (available from specialty bee suppliers) to facilitate cleaning and inspection of nest contents, or they may be left unlined. If left unlined, set out new blocks each year, while rotating the older blocks for cleaning. Wash the blocks in a mild bleach solution, then redrill the holes. This will help to reduce parasites, fungi, and diseases that might affect the developing bees in their brood cells. Before cleaning, make sure the bees have emerged from last year's nests by looking for emergence holes.

Location of the nesting sites is important. Bee blocks and stem bundles should be placed where they are sheltered from the worst of the weather, with entrance holes facing towards east or southeast, so they get the morning sun. The nests can be any height from the ground, but between three and six feet is convenient. Mount them on a building, fence, stake, or tree. Fix them firmly so they don't shake in the wind. Blocks can be left year round or removed and put in a dry, unheated space for the late fall and winter, then returned to the field the following season.

How to Build A Bee Block



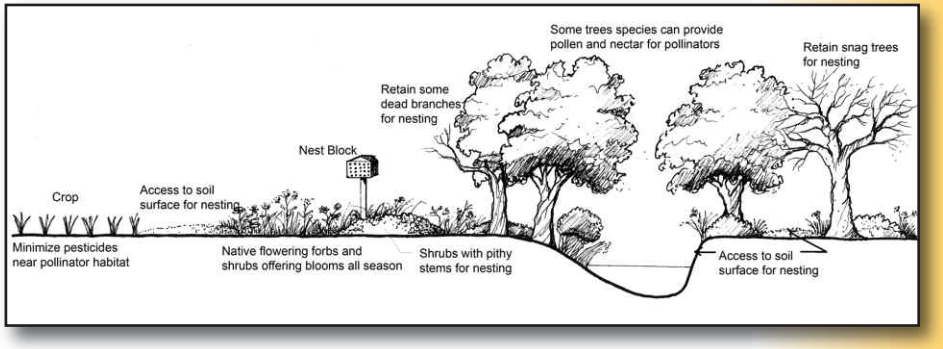
Bringing it all Together: Farmscaping for Bees

By planning and implementing a variety of bee-friendly landscape features, you can greatly improve the habitat for bees on your farm. Farmscaping for bees can be accomplished by providing plantings, nest sites, and other important resources in close proximity to each other and to crop plants. It is important to provide corridors that connect patches of habitat whenever possible. Larger areas of habitat ensure a greater likelihood that forage, nest sites, and nest building materials will be available within the bees' flight range and throughout the flight season. You should strive for a minimum width of 20 feet for any linear forage plantings, field borders, or buffers, but make them as wide as is feasible.

Native bee resource needs and the habitat features that provide them.

Resource	Habitat Features
Nectar, Pollen	Diverse plantings or natural communities of native flowers, shrubs, and trees with different floral shapes and overlapping bloom periods.
Mud	Nearby wetlands, streams, ponds, or ditches.
Nest Sites	Bare soil, sandy areas, muddy banks, stone piles or old stone walls, dead and dying trees, overgrown grassy areas, man-made nest sites, diverse native vegetation.
Shelter and Overwintering Sites	Windbreaks, hedgerows, woodlots, logs, rock piles, stumps, dead trees.
Habitat Continuity	Food sources near potential nesting sites (less than 500 feet is ideal for all bees, but less than ½ mile is acceptable for bumble bees). Habitat patches, from large natural areas to small plots, linked by corridors of undisturbed vegetation to reduce fragmentation.

Ideal bee habitat on the farm



Cost-Share Practices: Making them Bee-Friendly

There are many federal, state, and private programs available that can provide financial assistance to landowners for installation of conservation practices. Most of these practices can be adapted for bee habitat needs. Some of the cost-share practices that are valuable for bees include:

Field border planting (shown)
Filter strip planting
Hedgerow planting
Shallow-water wetland creation
Wetland restoration
Critical area planting
Riparian herbaceous cover development
Early successional habitat development
Riparian forest buffer planting
Upland / Wetland wildlife habitat management

Contacts for NRCS are listed at the end of this booklet. Ask about how you can incorporate native bee conservation into NRCS projects. Delaware Department of Agriculture staff members are also available to help you design bee habitat enhancements on your farm. The Delaware DNREC private lands biologist can assist you with finding public and private cost-share assistance for conservation projects. Consider developing a plan that will incorporate the needs of native bees into your farm management.

More Information About Conserving Native Bees:

A companion booklet, ***Delaware Native Plants for Native Bees***, is available from the Delaware Department of Agriculture. Contact them at the address listed below to obtain a copy, or visit the website: http://dda.delaware.gov/plantind/pollinator.shtml

The Xerces Society provides a wealth of information on pollinator conservation at their website: www.xerces.org

Additional native bee information can be found on the Mid-Atlantic Apiculture Research and Extension Consortium's website at: http://maarec.cas.psu.edu/Pollination.html

The following publications are recommended:

MacCulloch, Bonnie. 2007. *Farming for Native Bees in Delaware*. Dover, DE: Delaware Department of Agriculture. Available from http://dda.delaware.gov/plantind/pollinator.shtml

Mussen, E.C., M. Spivak, D.F. Mayer, and M.T. Sanford, eds. 1999. *Bee Pollination in your Garden*. AAPA Technical Bulletin No. 2. http://entomology.ucdavis.edu/aapa/aapapubs.cfm

Riedl, H., E. Johansen, L. Brewer and J. Barbour. 2006. *How to Reduce Bee Poisoning from Pesticides*. Oregon State University http://extension.oregonstate.edu/catalog/pdf/pnw/pnw591.pdf

Vaughan, M., M. Shepherd, C. Kremen and S.H. Black. 2007. *Farming for Bees: Guidelines for Providing Native Bee Habitat on Farms*. 2nd ed. http://www.xerces.org/pubs_merch/Farming_for_Bees.htm

Vaughan, M. and S.H. Black. 2006. Agroforestry Note 32: *Sustaining Native Bee Habitat For Crop Pollination*. USDA National Agroforestry Center. http://www.unl.edu/nac/agroforestrynotes/an32g06.pdf

Vaughan, M. and S.H. Black. 2006. Agroforestry Note 33: *Improving Forage For Native Bee Crop Pollinators.* USDA National Agroforestry Center. http://www.unl.edu/nac/agroforestrynotes/an33g07.pdf

Vaughan, M. and S.H. Black. 2007. Agroforestry Note 34: *Enhancing Nest Sites For Native Bee Crop Pollinators*. USDA National Agroforestry Center. http://www.unl.edu/nac/agroforestrynotes/an34g08.pdf

Vaughan, M. and S.H. Black. 2007. Agroforestry Note 35: *Pesticide Considerations For Native Bees in Agroforestry*. USDA National Agroforestry Center. http://www.unl.edu/nac/agroforestrynotes/an35g09.pdf

Cost-share and Technical Assistance Programs:

DNREC:

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DNREC Division of Fish and Wildlife
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New Castle County Agriculture Center
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Fax: 302-834-0783

Kent County Agriculture Center
800 Bay Road, Suite #2
Dover, Delaware 19901-4667
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Sussex County Agriculture Center
21315 Berlin Road, Unit #3
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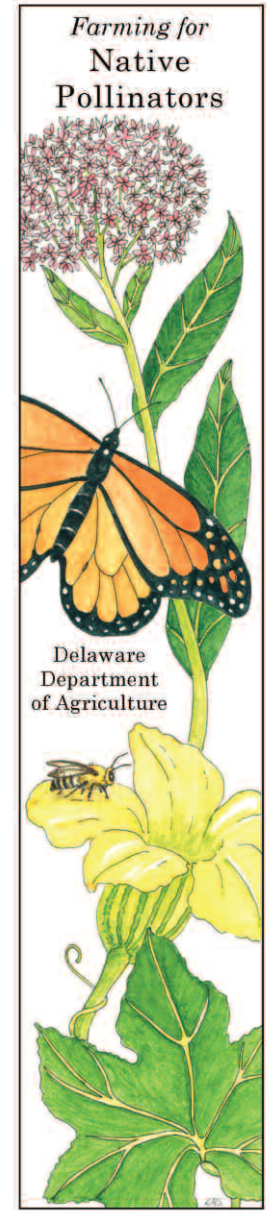

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This booklet was prepared by Matthew Sarver, in collaboration with the DDA Pollinator Project Team: Dewey Caron, Faith Kuehn, Heather Harmon, Bonnie MacCulloch, and Robert Mitchell. Some text was adapted from various Xerces Society publications on native bees with the assistance of Mace Vaughan, Conservation Director of the Xerces Society.

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Front Cover:
Top row (l-r): Pumpkins, Hannelore Doege; Native bee on Aster, *Symphyotrichum* sp., Susan Washinski; Mason bee, *Osmia collinsiae*, T'ai Roulston. Middle: Pollinator forage planting near Harrington, DE, Randolph Ciurlino. Bottom: Black-eyed Susan, *Rudbeckia hirta*, David Smith.

Back Cover:
Sweat bee, *Agapostemon splendens*, Sean McCann.

Page:
1: Top to bottom: Honey bee, *Apis mellifera*, David Cappaert; Sweat bee (Halictidae), Sean McCann; Bumblebee, *Bombus fervidus*, David Cappaert
2: (Top to bottom): Bumble bee, *Bombus impatiens*, David Cappaert; Sweat bee, Halictidae, Sean McCann; Mining bee, *Andrena barbilabris*, Nicolas J. Vereecken; Mason bee, *Osmia collinsiae*, T'ai Roulston; Digger bee, *Melissodes* sp., Edward Trammel; Carpenter bee, *Xylocopa virginica*, Matthew Sarver.
3: Pumpkin patch, Matthew Shepherd, Xerces Society.
4: Top to bottom: Apple orchard, Doug Wilson - USDA; Tomatoes, David F. Warren - USDA; Watermelon, Larry Rana - USDA; Squash bee, *Peponapis pruinosa*, Elizabeth Andrews.
5: Bee at watermelon blossom, Laura Scudder
6: Conservation buffer, Roger Hill - USDA NRCS.
7: Tractor with spray boom, Keith Weller – USDA ARS.
8: Mason bee, *Osmia aglaia* on white clover (*Trifolium* sp.), Mace Vaughan, Xerces Society.
9: Stream without conservation buffer, Lynn Betts – USDA NRCS; Stream with conservation buffer, Lynn Betts – USDA NRCS.
10: Tilled field, Delaware, Matthew Sarver; No-till corn field with hedgerow and woodlot, Delaware, Matthew Sarver.
11: Buckwheat, *Fagopyrum esculentum*, David G. Smith; Farm woodlot, Delaware, Matthew Sarver; Sweat bee, *Augochlora pura* in rotten stump nest, Matthew Sarver.
12: Bumblebee, *Bombus* sp., on Sweet Pepperbush, *Clethra alnifolia*, David G. Smith; Butterfly Milkweed, *Asclepias tuberosa*, David G. Smith.
13: Mining bee, *Andrena* sp. ground nest, Matthew Shepherd, Xerces Society; Pile of soil, Matthew Sarver; Small carpenter bee, *Ceratina cyanea* twig nest, Nicolas J. Vereecken Stem bundle, Mace Vaughan, Xerces Society.
14: Bee block diagram, Matthew Sarver; Bee block in the field, Mace Vaughan, Xerces Society.
15: Bee habitat diagram, USDA National Agroforestry Center.
16: Field border, Dot Paul – USDA NRCS; Conservation on the Farm, original artwork, Sean Patton – USDA NRCS.
18: DDA Pollinator Project Logo, original artwork, Kelly Mills Sverdnk

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NOTES: