

CHAPTER 2

BEST PRACTICES FOR FORAGE AND HABITAT

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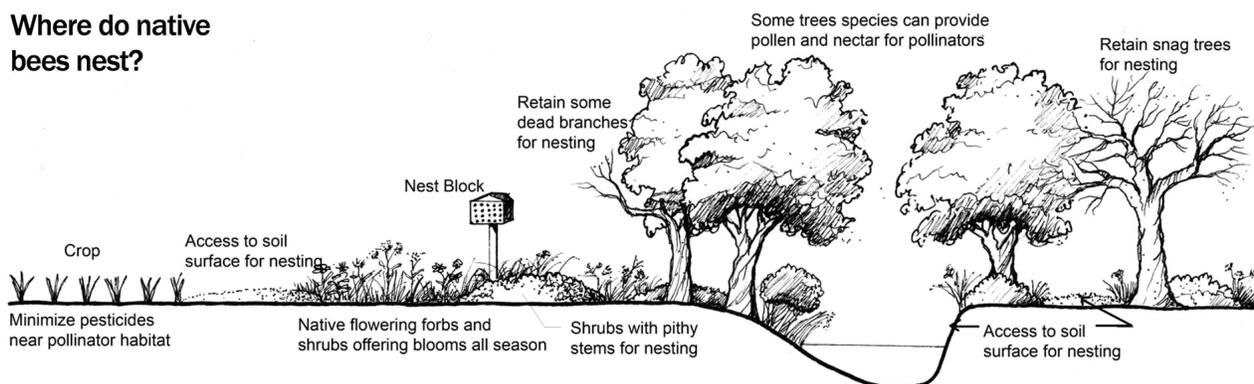
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INTRODUCTION

To support healthy and diverse communities of pollinators, landscapes must provide appropriate nesting sites, abundant and high quality nutritional resources (flowering plants), a consistent supply of water, and minimal exposure to stressors such as pesticides. Because the nesting and nutritional needs of different pollinator species are quite diverse, it is critical to ensure landscapes contain an abundant and diverse array of nesting opportunities and flowering plant species. We will focus on best practices to generate high quality nesting and forage habitat in different types of landscapes in this section. Information on how to minimize pesticide exposure can be found in the “Best Management Practices for Pesticide Use” section.

Wild bees can nest in the ground (and thus require soil that can be easily dug out to form tunnels or chambers), in cavities found the ground (including empty rodent nests), trees or rocks, or they may excavate and nest in stems or twigs. Approximately 30% of native bee species in the US nest in wood, while 70% nest in the ground. Diverse nesting sites will be readily available in complex habitats (such as forest edge or hedgerows), but it is also possible to provide nesting boxes or other suitable sites in smaller areas, such as home gardens. For more information, see resources for creating nest sites developed by the [Xerces Society](#), the [USDA National Agroforestry Center](#), or [Penn State](#).

Where do native bees nest?



Bees can nest in diverse sites in the landscape. Figure from USDA National Agroforestry Center, AF Note 34

Pollinators depend on flowering plant species for their food. All species of pollinators (bees, flies, butterflies, moths, hummingbirds, bats, etc) use nectar as their primary source of carbohydrates. Bees in particular also collect pollen from flowering plants as a source of protein, fats, and other micronutrients. High quality and abundant pollen is critical for female bees to produce eggs and rear their brood.

Pollinators vary greatly in

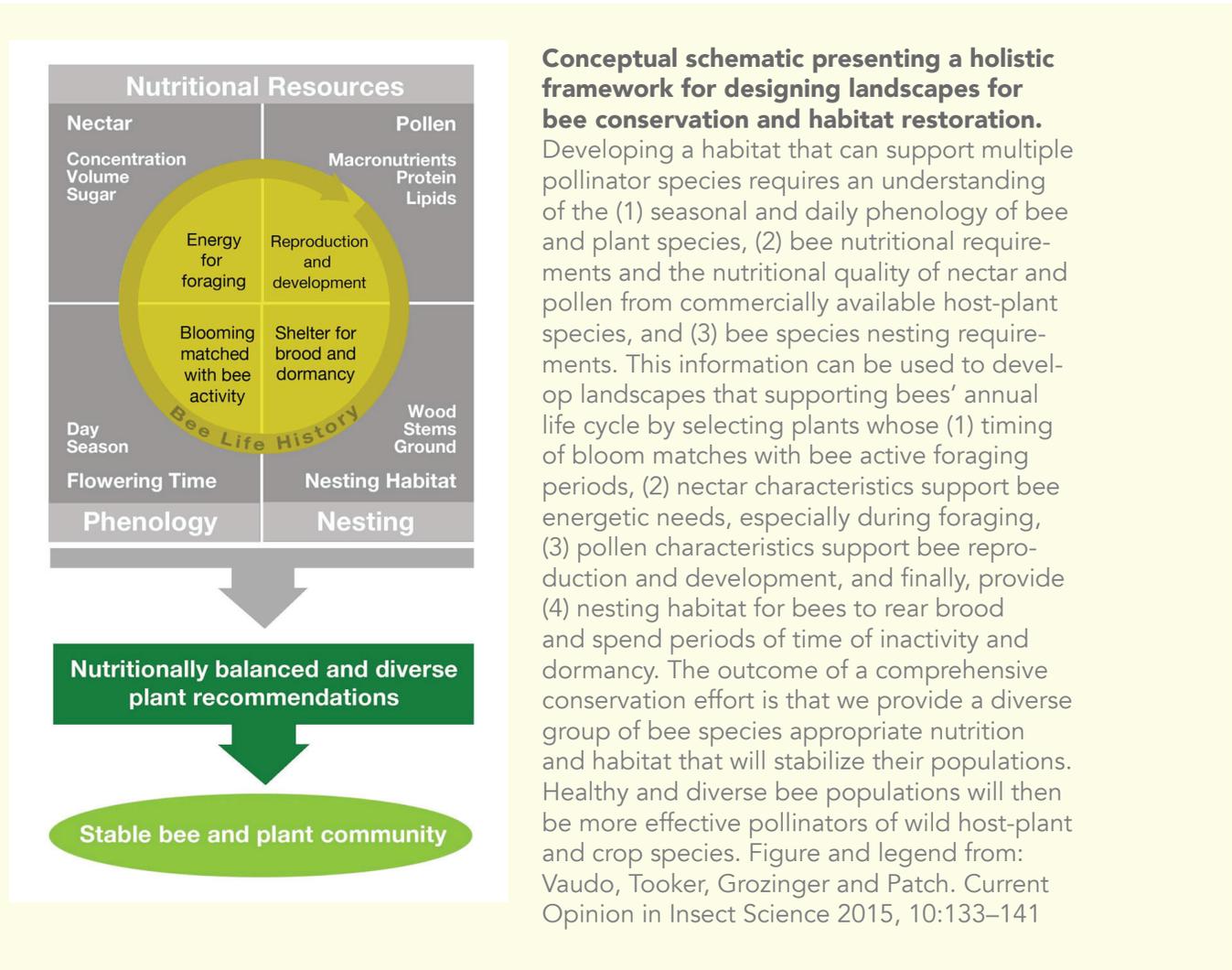
- the time of year that they are active (for example, orchard bees are active in the early spring while bumble bees are active from spring to fall)
- the time of day that they are active (moths are active at night, squash bees are active in the early morning and honey bees are active from mid-morning to evening)
- the type of flowers they can access (hummingbirds can access flowers with long corollas while bees cannot, bumble bees can perform “buzz pollination” and thus can access pollen from species such as tomatoes, while honey bees cannot)
- the color of flowers they are most attracted too (flies tend to be more attracted to white flowers while hummingbirds tend to be attracted to red flowers)
- the scent of the flowers they are most attracted to (bees prefer floral odors, flies prefer fetid odors, and some night flying moths are attracted to the carbon dioxide released by night flowering plants).
- their nutritional needs (bumble bees prefer pollen with higher protein content than honey bees, while hummingbirds prefer different kinds of sugars than bees).

Similarly, flowering plant species vary in their phenology (whether they bloom in the spring, summer and fall), the time of day that their flowers are open and accessible to pollinators, the flower color, the shape and physical structure of the flower, floral scents, and the quantity and nutritional quality of the nectar and pollen. **Thus, supporting diverse and healthy pollinator species requires abundant and diverse flowering plant species that bloom during the entire growing season.** There are multiple resources available to help identify appropriate flowering plant species to include in different landscapes, which will be discussed in more detail below. Additionally, regional guides to pollinator plants and habitat restoration guides can be found on [Xerces' Pollinator Resource Conservation Center](#).

Finally, some pollinators require special food sources for their young. For example, butterfly and moth caterpillars often feed in specific plant species: for example, monarch caterpillars feed on milkweed, while swallowtail caterpillars feed on plants in the carrot family, such as wild parsnip, Queen Anne's Lace, parsley, and dill. **Thus, it is important to include a diversity of caterpillar host plants to support these pollinator species.**

Issues related to restoring and maintaining landscapes to support diverse pollinator communities were recently discussed in a publication from [Penn State](#), and summarized in the figure below. Below, we discuss approaches to support

pollinator communities in different contexts, including urban, roadsides and right of ways, agricultural and natural landscapes.



BEST PRACTICES FOR URBAN AND SUBURBAN LANDSCAPES

Gardens and green spaces in urban areas can support diverse pollinator communities; in fact, some studies have found urban areas support more diverse communities than surrounding rural areas. These diverse pollinator communities can serve to better connect the public with the natural world, provide critical learning opportunities for K-12 students, ensure pollination of fruits

and vegetables in urban gardens and farms, and provide additional habitat and forage for pollinator communities in surrounding areas. Furthermore, simple changes to land management and land use practices can dramatically increase the habitat and forage available in urban areas, and thus lead to more community involvement and engagement.

In Pennsylvania, individuals can certify their pollinator gardens through the Penn State Master Gardeners and find many valuable resources for designing pollinator gardens on the [PA Pollinator Garden Certification website](#). Additional resources, including sample gardens designs, can be found in the [Snetsinger Butterfly Garden website](#). Individuals are encouraged to visit local gardens and arboretums to learn more about pollinator gardens and native Pennsylvanian plants, such as the [Pollinators' Garden at the Arboretum at Penn State](#), the [Phipps Conservatory and Botanical Garden](#) in Pittsburgh, and [Longwood Gardens](#) outside of Philadelphia.

Individuals are also encouraged to advocate for Township or Municipal native plant or pollinator habitat ordinances that provide for allowing areas around homes and businesses to incorporate a variety of plant types (not just short grasses and lawns) as long as they are managed and not neglected. Such recommendations for “neighborly natural landscaping” are provided from [Penn State Extension](#), and York County, PA recently developed a sustainable landscape [model ordinance](#). Incorporated towns, cities and communities can become certified with the [Bee Friendly PA program](#) and with [Bee City USA](#). Below, we provide specific recommendations for producing and maintaining pollinator habitat and forage in different types of urban areas.

Lawn Care. Traditional lawns with low-cut grass and no flowering plants provides no nutritional resources for pollinators and limited nesting opportunities. Homeowners and landscapers may choose consider alternative strategies for managing these areas, such as incorporating “natural” landscapes. If lawns are preferred, to support pollinators it is recommended that homeowners:

- Allow plants such as dandelion, dead nettle and clover to bloom in lawns. They provide an important early source of pollen and nectar for pollinators.
- Mow as high as possible (greater than 3”) to allow for blooming plants and nesting and overwintering habitat.
- Use an Integrated Pest Management (IPM) and Integrated Vegetation Management (IVM) approach to manage pests, diseases, and weeds (see Best Management Practices for Pesticide Use section). An IPM/IVM approach will reduce the use of pesticides, including herbicides,

and limit the exposure of pollinators to any pesticides that must be applied. For lawns in particular, mowing off flowers before applying pesticides can reduce exposure of foraging bees (though ground nesting bees will still be impacted).

Gardens, Landscapes, and Golf Courses. As noted above, there is a wealth of information on “neighborly natural landscaping” through [Penn State Extension](#) as well as how to create pollinator forage and habitat (including recommended plant lists) in gardens and larger landscapes on the [Pennsylvania Pollinator Garden Certification website](#). Homeowners and landscapers can also obtain additional information through the [Penn State Master Gardeners](#) program, and through classes and workshops at the [Phipps Conservatory and Botanical Garden](#). Briefly, recommendations for these gardens include

- Growing a diversity of flowering plant species that bloom throughout the season to provide nectar and pollen for foragers.
- Including host plant species for butterfly larva (i.e. monarch caterpillars and milkweed)
- Preferentially use native plant species for your particular region, since these are generally best suited to support pollinators and to grow under typical Pennsylvania conditions. However, other plants can also be beneficial and should be included as needed to increase forage diversity and quality.
- Avoid plant species that are considered invasive or noxious, and remove these if they are found in your property. A list of these plants is provided on the [DCNR Invasive Plants List](#). Fact sheets with information on how to identify and control invasive plants are available at the [DCNR Wild Plants Website](#).
- Double flowered plants and some hybridized plants generally do not provide much nectar and/or pollen. Include other plants in your garden in addition to these.
- Consider all types of plants - trees, shrubs, vines, perennials, annuals and herbs -that contribute to the habitat, taking advantage of all areas and layers. Plant in beds, containers and hanging baskets.
- Ornamental grasses, shrubs and non-flowering plants also contribute to the garden providing nesting sites for pollinators and protection from the weather.
- Include seasonal variety. Fall is particularly difficult for some pollinators as summer plants are declining and overwintering pollinators are preparing for the cold. Monarchs are also migrating south during this time.
- Use an Integrated Pest Management (IPM) and Integrated Vegetation Management (IVM) approach to manage pests, diseases, and weeds

(see Best Management Practices for Pesticide Use section). Mechanical and cultural methods are often very effective for addressing a variety of issues.

- Allow plants to stand over the winter. Delay garden clean-up until plants are starting to emerge (late spring) as many pollinators use standing gardens and debris as overwintering sites.
- Additional information on managing golf courses for pollinators can be found in “[Optimizing Pest Management Practices to Conserve Pollinators in Turf Landscapes: current practices and future research needs](#)” and in the [Audubon Cooperative Sanctuary Program for Golf](#).

Urban Landscapes. Increasing green spaces in urban areas are associated not only with improved biodiversity but also with improved happiness and health of [people living in these areas](#). Given the diversity of plant species that support pollinators, it is relatively straightforward to simultaneously increase green space and vegetation while improving pollinator habitat and forage. In particular, urban planners should:

- Choose native species that have pollinator benefit when choosing yard and street tree species. A listing of native tree and woody ornamental species that support pollinators can be found in publications from the extension programs at [Michigan State University](#) and [University of Kentucky](#).
- Remove invasive species and replace with beneficial native plant species.
- Install green roofs where possible. Choose flowering and pollinator host plant species where possible.
- During public comment phase of public space design projects, work with municipal officials and design teams to specify plants that are beneficial to pollinators. York County, PA recently developed a sustainable landscape [model ordinance](#).
- Work with, or join city park volunteer “friends” groups to promote pollinator habitat restoration and creation. An example of such an organization is the [Friends of Wissahickon](#).

BEST PRACTICES FOR ROADSIDES AND UTILITY RIGHTS OF WAY

Roadsides cover more than 10 million acres of land in the US. Pennsylvania has more than 40,000 miles of roads, and is one of the top five states in the nation for road miles. More than 100,000 acres of roadside lands are managed in Pennsylvania. Additional land is provided by utility rights of way (ROW) and corridors, which create open space across diverse landscapes. These areas can be managed to provide habitat and forage for pollinators and other wildlife as well as increase aesthetic appeal. In 2015, the “Fixing America’s Surface Transportation Act” (FAST Act-Public Law 114-94, Section 1415) directed the Secretary of Transportation to use existing authorities, programs and funding to encourage State Departments of Transportation to facilitate efforts to improve habitat and forage for pollinators.

Roadsides and ROWs can provide habitat and forage for pollinators in areas where there may be little appropriate habitat, and provide “corridors” connecting different regions, thereby supporting pollinator movement and allowing pollinators to access foraging resources and habitat in larger areas. Indeed, several studies have suggested that improving habitat on roadsides can increase the abundance and diversity of pollinators. While pollinators can be killed from collisions with cars when they cross roads, studies have indicated that the population losses from car collisions are small, and increasing pollinator habitat along roadsides can actually reduce the movement of pollinators across roads. Roadsides can also be managed to both support pollinators and limit larger wildlife, such as deer: for example, reduced mowing can increase the abundance of flowering native plants and reduce the amount of plants that are palatable for deer.

Managing roadsides and ROWs to support pollinator populations is a challenging task. Land managers need to balance the needs of drivers and utility companies (for example, areas around roads need to be maintained to ensure visibility, safety, access, and reduce erosion) and invasive species management, with support of the nutritional and habitat needs of diverse pollinator species. Moreover, roadsides and ROWs are located in diverse habitats, not all of which are appropriate for supporting pollinator habitat, and which likely contain residues of gasoline, motor oil, ethylene glycol as well as salt and sand from winter roadside management. Finally, roadsides and ROWs cover vast amounts of land, and thus it is most appropriate to consider management of selected locations and areas which are amenable to management and will provide the most benefit to pollinators.

Detailed information on managing roadsides and rights of way for pollinators can be found in resources from [Pollinator Partnership](#), the [Xerces Society](#), [Monarch Joint Venture](#) and the [US Department of Transportation Federal Highway Administration](#). Listed below are general guidelines to consider while developing plan to restore, maintain and expand forage and habitat for pollinators along roadsides and ROWs.

- Build a coordinated network of individuals and groups interested in restoring and maintaining pollinator habitat. Volunteer groups can partner with [Pennsylvania Department of Transportation \(PennDot\)](#) through the “[Adopt and Beautify](#)” Program, while businesses and corporations can partner with PennDOT through the “[Sponsor a Highway](#)” Program.
- Evaluate potential sites and select an optimal site. Site selection criteria can include soil quality, proximity to other pollinator habitat, sunlight and water availability. It is also important to contact the US Fish and Wildlife Service to confirm that the site is not the habitat of a sensitive species. A site selection rubric can be found in these documents from [Pollinator Partnership](#) and [Monarch Joint Venture](#).
- Develop a restoration and management plan, with clear expectations for timelines, budgets and goals. Expect that the project will require 3-5 years of sustained effort.
- Include a selection of plants that will provide nectar and pollen resources for pollinators throughout the growing season, as well as plants that serve as food sources for caterpillars of key pollinator species (such as milkweeds for monarch butterflies).
- Develop strategies for controlling invasive plant species at appropriate levels (for example, the evaluation plan may state that up to 20% of plant species in the site can be non-native species before management is needed).
- Provide nesting habitat for pollinators, such as areas with bare soil for ground-nesting species.
- Roadsides and ROWs will require periodic mowing. Develop a plan that ensures the needs of stakeholders are met while optimally supporting pollinators. For example, mowing once a year in the fall – after bloom - may reduce negative impact on pollinators, reduce the presence of invasive species, while ensuring visibility and safety. Alternatively, sections can be mowed at different times, to ensure that some flowering plants and habitat are always intact.
- Use an “[Integrated Vegetation Management](#)” and “[Integrated Pest Management](#)” approach to reduce the use of herbicides and pesticides in these areas, while still maintaining populations of invasive plant species and insect pests at below threshold levels. Use methods that reduce the impact of pesticides on pollinators, eg, minimizing

drift, including non-pesticide buffer zones, spraying only a portion of the area. See information in “Best Management Practices for Pesticide Use” for more information. Information on IVM approaches can be found in PennDOT’s “[Invasive Species Best Management Practices](#)” publication.

- Develop an evaluation plan to document the success of the restoration and maintenance efforts.
- Celebrate the success of the management plan through social media and events, to encourage other organizations to participate in similar efforts.

BEST PRACTICES FOR AGRICULTURAL LANDSCAPES

Approximately 75% of major agricultural crops require or benefit from pollinators to set seed and produce fruit, and all crops can benefit from the arthropods that prey on or parasitize pest species, thereby reducing the negative impacts of these pest populations. Thus, there can be tremendous economic advantages to conserving and expanding populations of beneficial arthropods (managed and wild pollinators, predatory and parasitoid species) in agricultural landscapes.

There are many strategies growers can use to enhance and expand forage and habitat for pollinators in their farms. Growers can install hedgerows on the edges of agricultural fields, meadows in areas that are not in production, and add flowering cover crops within agricultural fields. All of these have multiple benefits in addition to supporting diverse communities of pollinators and beneficial insects, including serving as windbreaks and limiting water and soil runoff and erosion. Detailed information on how to select and prepare sites, choose appropriate plant species, install pollinator habitat and forage, and maintain these sites can be found in the following documents:

- Regional guides to pollinator plants and habitat restoration guides can be found on [Xerces’ Pollinator Resource Conservation Center](#).
- [USDA-NRCS/Xerces Society: Hedgerow Planting for Pollinators: Pennsylvania Installation Guide & Job Sheet](#)
- [USDA-NRCS/Xerces Society: Conservation Cover for Pollinators: Pennsylvania Installation Guide & Job Sheet](#)

- USDA-NRCS/Xerces Society/SARE: Cover Cropping for Pollinators and Beneficial Insects
- USDA National Agroforestry Center’s factsheet on Windbreaks
- USDA National Agroforestry Center’s factsheet on Enhancing Nest Sites for Native Bee Crop Pollinators
- USDA National Agroforestry Center’s factsheet on Improving Forage for Native Bee Crop Pollinators
- USDA National Agroforestry Center’s factsheet on Sustaining Native Bee Habitat for Crop Pollination
- Several programs are available to help growers install pollinator forage and habitat on their lands. These include:
 - USDA-FSA Conservation Reserve Program (CRP)
 - USDA-NRCS Conservation Stewardship Program (CSP)
 - USDA-NRCS Environmental Quality Incentives Program (EQIP)
 - USDA-NRCS Conservation Innovation Grants Program (CIG)
 - USFWS Partners for Fish and Wildlife Program

BEST PRACTICES FOR NATURAL LANDSCAPES.

Pennsylvania has 121 state parks spanning 300,000 acres, 2.2 million acres of state forest, and 1.5 million acres of state game lands. However, approximately 70% of Pennsylvania’s forested land is privately owned, and thus it is critical that a broad range of stakeholders are engaged in efforts to protect pollinators in pollinator conservation, especially considering that no state agency has legal authority over Pennsylvania’s native terrestrial insects. This section provides recommendations for best practices to support and expand pollinator populations in larger tracts of relatively undeveloped forest and other natural habitats, including fields, wetlands, and riparian zones.

In addition to the information provided below, there are many comprehensive resources available that cover a broad range of management recommendations for pollinators on natural lands. The Pennsylvania Natural Heritage Program’s (PNHP) Habitat Management for Pollinators[48] provides information on a variety of best management practices including ways to promote habitat variety to support all life stages of pollinators, maintain open habi-

tats, control invasive plants, protect pollinator diversity and rare species, and select native and local plants for pollinators. Two comprehensive guides on habitat management for pollinators include the USDA Natural Resource Conservation Service's [Pollinator Biology and Habitat](#), and the Xerces Societies' [Pollinators in Natural Areas: A Primer on Habitat Management](#).

Incorporate Pennsylvania native plants, shrubs, and trees into wildlife habitat and reclamation efforts on public lands. Planting projects in forests and other natural habitats should include a variety of native trees, shrubs, grasses or forbs (wildflowers) to increase ecosystem functions and habitat diversity for pollinators and other wildlife. Native pollinators and other insects have evolved over time with native plants, and native plants are adapted to local climate and soil conditions. Furthermore, some native species can grow in very dry and nutrient-poor sites, do not need soil amendments, and rarely require fertilizer for establishment. Look for herbaceous and woody plants that will create continuous flowering throughout the growing season to ensure that nectar sources are present from spring through fall. Select a variety of plants with different flower colors and shapes that will bloom within each of the three growing seasons. When replanting disturbed sites, consider including an annual native like partridge-pea which can flower during the first growing season before other native perennials become established. As a general rule, maintenance activities such as mowing along roadsides and in rights of ways, and burning or mowing in early successional habitats that support native flowering plants, should be conducted in a patchy manner and outside of the growing season when possible.

The Pennsylvania Bureau of Forestry [Planting and Seeding Guidelines document](#) provides recommendations on how to restore a disturbed site with native grasses, sedges, rushes, flowering plants, shrubs, deciduous trees, and conifers. The PNHP Habitat Management for Pollinators[49] provides additional recommendations on how to select plants that will supply food to pollinators in their adult and immature life stages, and how to maintain pollinator habitats through management practices such as rotational mowing. The USDA Natural Resource Conservation Service's [Pollinator Biology and Habitat document](#) provides simple guidelines on how to assess plant community diversity, select plants for a site, and design the planting layout to maximize attractiveness to pollinators.

Prevent new invasive plant infestations and control existing ones. Some invasive plants can provide a temporary bloom of flowers for adult pollinators, but in the long term do much more harm than good by out-competing native caterpillar food plants and adult nectar plants and degrading other important habitat qualities. For a list of plants that are not native to the state,

grow aggressively, and spread and displace native vegetation, see the [DCNR Invasive Plants List](#). Fact sheets with information on how to identify and control invasive plants are available at the [DCNR Wild Plants Website](#). Specific information on locations of invasive species and control efforts can be found at [iMapInvasives](#).

Herbicides are necessary tools for land management and controlling invasive species, but these pesticides can have negative impacts on non-target species (including the plants that pollinators depend on for nutrition) and thus should be used as part of an **Integrated Vegetation Management** (IVM) approach. For more details, see the “Best Practices for Pesticide Use” section. Additionally, the following resources are comprehensive guides for controlling invasive plants and the use of herbicides in natural habitats:

- [Safe Herbicide Handling in Natural Areas: A Guide for Land Stewards and Volunteer Stewards](#)
- [Upkeep and Maintenance of Herbicide Equipment: A guide for natural area stewards](#)
- [Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas](#)

Deer Management. Deer browse on trees, herbaceous plants and shrubs can limit the food resources needed by local populations of adult and larval insects. Protecting pollinator nectar and host plants from excessive deer browse is a difficult challenge in many regions of Pennsylvania. Fencing and tree tubes are often necessary to protect investments in native plantings. Good overviews of how white-tailed deer shape their environment are available at [DCNR’s Role in Deer Management: Conserving Pennsylvania’s Forests and Native Plants](#), in Penn State Extensions’ [White-Tailed Deer](#), and in the USDA Forest Service Northeastern Area’s [Impacts of White-Tailed Deer Overabundance in Forest Ecosystems: An Overview](#). Two publications that provide more detailed deer management recommendations include The Natural Lands Trust’s [Deer Management Options](#) and the Cornell Cooperative Extension’s [White-tailed Deer Wildlife Damage Management Fact Sheet](#).