Pollinator Conservation and Farm System Planning

A growing emphasis within the Natural Resources Conservation Service (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 your farm. Pollinator habitat can also provide habitat for other wildlife such as birds, 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 (4) managing habitat for the benefit of a diverse pollinator community.

A general listing of native pollinator habitat requirements is contained in Table 1 below.

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.
Bumblebees	Nectar and pollen	Most nest in small, softball size cavities, 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 twin berry or penstemon	Trees, shrubs, and vines

Recognizing Existing Pollinator Habitat

Many growers may already have abundant 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 useful as pollinator habitat.

Existing Plant Composition. When assessing pollen and nectar resources, it is important to look at all 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 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 weed species, producers might consider allowing native and/or non-native forbs present on-site to bloom prior to crop bloom. Mowing forbs during crop bloom can stimulate subsequent forb blooming. For example; dandelions, clover, and other non-native plants are often good pollinator plants. Forbs can be mowed during crop bloom; however, one must weigh benefits for 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 bumblebees 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 bumblebees, 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.

Nesting and Overwintering Sites. Bees need nesting sites to support populations of native bees. Protecting and/or providing nest sites is as important as providing flowering species. Similarly, caterpillar host plants are necessary for strong butterfly populations.

The idea is to have nesting and forage resources in the same habitat patch; however, bees are adaptable to landscapes in which nesting and forage resources are separated. It is important that these two key habitat components are not too far apart.

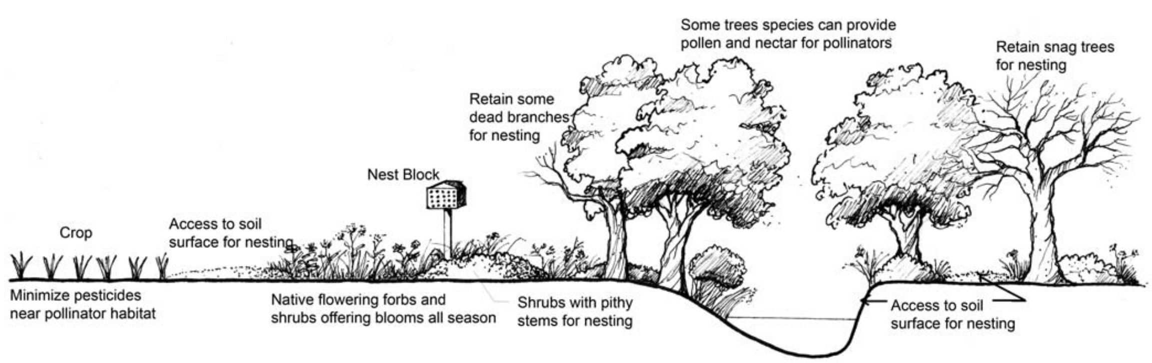
Native bees often nest in inconspicuous locations, e.g., many excavate tunnels in bare soil, others occupy tree cavities, and a few even chew out the soft pith of the stems of plants like elderberry or blackberry to make nests. It is important to retain as many naturally occurring sites as possible and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

Most of North America's native bee species (about 70 percent or 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 species nesting independently. However, some of these will be found in large aggregations with thousands nesting in the same area. Some species will also cooperate in sharing common nest entrances.

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 bee, agave or 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.

Bumblebees 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 bumblebees. 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.



From: Agroforestry Note—34: "Enhancing Nest Sites for Native Bee Crop Pollinators"

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.

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. Mowing blooms of crops and weeds prior to application of pesticides will reduce the threat to pollinators. 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, e.g., dewy nights may cause an insecticide to remain wet on the foliage and be more toxic to bees the following morning.

In general, while pesticide labels may list hazards to honeybees, potential dangers to native bees are often not listed, e.g., many native bees are much smaller in size than honeybees and affected by lower doses. Also, honeybee 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.

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 headlands 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 worse 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, e.g., 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.

Minimizing the Impact of Mowing, Haying, Burning, or Grazing. Only a portion 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 re-colonization 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.

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 soil-borne crop pathogens (i.e., *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.

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 (e.g., elderberry, raspberry, blackberry, or box elder) will go a long way towards supporting these solitary bees.

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.

Locally adapted native plants are often preferred 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, as long as non-native species are naturalized and not invasive.

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.

- 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 bumblebees. North-facing slopes are often cooler and tend to be dominated by trees.

- Sun Exposure—Because 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.

- 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 soil-borne pathogens that may inhibit plant development. Where such conditions exist, pathogen-resistant plant species should be considered. Some legumes may require soil microorganisms such as rhizobium bacteria for successful establishment. 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.

- 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.

- 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 waterways can also be planted with pollinator-friendly plants rather than turf grass.

- 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, hedgerow, or crop border) will often be more practical. A planning goal is to have 1 or 2 acres for every 25 acres of cropped field.

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.

- 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 bumblebees may forage up to a mile away from their nest. Thus, crops that depend heavily upon bumblebees for pollination, such as cranberries or blueberries, might still benefit from pollinator habitat located some distance from the field (although even bumblebees 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 wild lands, 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.

- 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.

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 pests, disease, and weed epidemics and 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 percent of a single plant species, no more than 20 percent of single genera, and no more than 30 percent of a single family.

- 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. In some studies, bee diversity also 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. Kansas plantings will include a minimum of 10 flowering plant species including forbs, legumes, shrubs, and/or trees. Plantings will contain a minimum of three species that start flowering in May; three species that flower in June, July, and August; and three species that flower in September. For forb and/or legume seeding rates and recommendations, refer to Table 2. Flowering trees and shrubs can be counted as part of the species and flowering requirement. In Kansas, shrubs and trees are considered early flowering species. Refer to Conservation Practice 612, Tree/Shrub Establishment, and Kansas Forestry Technical Note KS-9, Tree/Shrub Establishment and Maintenance Guidelines, for technical standards and specifications. For species recommendations, see Kansas Forestry Technical Note KS-10. Site-adapted native shrubs (all considered as early season flowering) include but are not limited to American plum, elderberry, redosier dogwood, buffalo berry, golden currant, skunk bush sumac, chokecherry, gray dogwood, and woods rose.

It is especially important to include plants that flower early in the season. Many native bees such as bumblebees 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 bumblebee 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 bumblebees are strong and numerous going into winter hibernation.

Plant clusters of a single species when possible. Research suggests that clump-plantings of at least 3- by 3-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 even more ideal for attracting pollinators and providing efficient foraging.

- Inclusion of Grasses—Where fields for pollinator plantings are less than 2 acres in size or are plantings within a larger native grass field, inclusion of grasses in the pollinator mix is not recommended. When planting an entire field (greater than 2 acres), the inclusion of 10 to 50 percent native bunch grass may be added to the mix. Erosion potential due to soils, slope, rainfall, along with producer’s objectives and capabilities should be considered when developing mixes. Soils with an erosion index of 86 or greater should contain a minimum of 25 percent native bunch grass in the pollinator mix. 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. Kansas ecological site descriptions are also a good source for herbaceous plant community information. Most native plant communities generally contain at least one dominant grass in their compositions. These grasses often provide forage resources for beneficial insects including larval growth stages of native butterflies, potential nesting sites for colonies of bumblebees, 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 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. With the inclusion of native grass in the mix, additional management will be needed to maintain forbs. Planting early within the established planting dates will also favor forb development over grasses.

- Brush Piles—Brush piles provide nesting and overwintering sites for many pollinators. Insects burrow and lay eggs in bare ground below the pile and in branches and logs that make up the pile. It is recommended that brush piles be constructed to be no less than 100 square feet and 3 feet tall. Brush piles should be limited to 1,500 square feet for every acre of pollinator habitat. If prescribed burning is used to manage pollinator habitat or adjacent grassland, the prescribed burn plan should address the brush piles. Woody vegetation may smolder for days after a burn has been completed. Unwanted woody and/or noxious vegetation that becomes established in brush piles will be controlled.

- Edge Feathering—Edge feathering is a treatment applied to trees within the edge of a forested area that are cut and allowed to fall onto an adjacent field creating excellent year-round security and thermal cover. Trees can be cut either at the ground or up to 4 feet above ground. Cutting of trees and felling so they remain connected to the tree base allows for re-sprouting and establishment of shrubby habitat. Recommendation is to fell trees exceeding a minimum height of 15 feet. Edge feathering will be completed in long, linear strips along the field edge (minimum of 50 feet). Care should be taken to control noxious plants and limit possible damage from fire. If prescribed burning is used to manage pollinator habitat or adjacent grassland, the prescribed burn plan should address the edge feathered areas. Woody vegetation may smolder for days after a burn has been completed. Exclude livestock from feathered edges. Killing existing grasses/vegetation (regardless of type) before edge feathering with an approved herbicide promotes favorable growing conditions for annual food plants and shrubs. If erosion is a concern, the site should not be considered for edge feathering.

Plant Selection and Seed Sources. Choose plants with soil and sunlight requirements that are compatible with the site where they will be planted. Due to availability of locally grown forbs, mileage and/or elevation restrictions found in Construction Specifications 550, Range Planting, are not applied to developing forb seeding mixes. Table 2 provides a starting point for selecting widely distributed and regionally appropriate pollinator plants to develop your pollinator planting mix. If these plants are not available, other adapted species not listed in Table 2 can be used with state resource conservationist's concurrence. Noxious and/or invasive species will not be included in planting mixes.

- 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.

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.

- Seed Sources—All seed analysis will be conducted in accordance with rules and regulations as prescribed by the Association of Official Seed Analysts (AOSA) and Kansas law. The Kansas Seed Law specifies the kind and amount of weed seed permitted, the requirement for a current analysis report, and labeling of all seed to show its purity, germination, date of last germination test, and weed seed content. 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 (within established mileage guidelines). Plants selected from local sources will generally establish and grow well because they are adapted to the local climatic conditions.

- 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 burlapped 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 burlapped 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.

- Avoid Nuisance Plants—When selecting plants, avoid ones that act as alternate or intermediate hosts for crop pests and diseases. For example, many rust fungi require two unrelated plant species to complete their life cycle. 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.

- 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, areas of low cost, or temporary bee pasture plantings that also attract beneficial insects which predate or parasitize crop pests.

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 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.

In general, these constructed ground-nest sites should receive direct sunlight and dense vegetation should be removed regularly, 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 ⅛ inch in diameter to almost ½ 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 should be constructed of preservative-free lumber and the hole depth should be at least 4 inches (up to 6 inches is even better). Holes should not be drilled all the way through the block and should also be spaced at least ¾ inch apart so that bees returning to the block from foraging can easily find their own nest tunnel.

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.

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 on 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.

Management and Maintenance of Pollinator Habitat

Many native plants require several seasons before their initial flowering. As they mature, bees, butterflies, and other pollinators like hummingbirds, will become increasingly common. 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 no more than ⅓ 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. Preferred time period for maintenance is early spring prior to the emergence of desirable pollinator plants. For detailed information on long-term site maintenance for pollinator habitat that addresses techniques for minimizing the impact of herbicide, fire, grazing, mowing, and other management activities, download *Pollinators in Natural Areas: A Primer on Habitat Management* at http://www.xerces.org/wp-content/uploads/2008/11/pollinators_in_natural_areas_xerces_society.pdf

Controlled, rotational grazing may also be a viable option for managing the plant community. Grazing should generally occur during the pollinator dormant season (winter and early spring) and at 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 Practices 338, Prescribed Burning, and 394, Firebreak, that separate the habitat into multiple sections.

Table 2—Native Forb/Introduced Legumes

There is a vast array of native forbs and introduced legumes to choose from in designing pollinator seed mixes. When developing mixes, limit introduced legumes to no more than 10 percent individually with total introduced legumes in a mix not to exceed 20 percent of the total. To increase diversity and benefits to pollinators, it is recommended that native forbs individually be limited to 10 percent of the mix. Native bunch grass may also be included in a pollinator mix at a rate of 10 to 50 percent of the mix, unless program seeding requirements differ. Form KS-ECS-4, Grass Seeding, can be used for planting mix documentation.

Table 2: Native and introduced forbs/legumes

Common Name	Scientific Name	Full Seeding pls/lb/ac	Bloom Period Early Mid Late	Flower Color	Mature Height (Feet)	Soils: Fine Medium Course	Annual, Perennial, or Biennial	Zones: West, Central, East	Notes:
Blacksamson	Echinacea angustifolia	7.0	M	purple	2	M-C	Perennial	W-C-E	Purple coneflower
Black-eyed Susan	Rudbeckia hirta	0.5	E-M-L	yellow	3	F-M	Perennial	W-C-E	
Butterfly milkweed	Asclepias tuberosa	13.0	M	orange	3	M-C	Perennial	C-E	
Canada goldenrod	Solidago canadensis	0.2	M-L	yellow	3.5	F-M-C	Perennial	W-C-E	
Canada milkvetch	Astragalus canadensis	3.0	E-M	white	4	M	Perennial	E	
Catsclaw sensitivebriar	Mimosa nuttallii	23.0	M	purple	2	M-C	Perennial	W-C-E	
Clasping coneflower	Dracopis amplexicaulis	0.5	E-M	yellow	2	F-M-C	Annual	C-E	
Compass plant	Silphium laciniatum	35	M-L	yellow	10	M-C	Perennial	C-E	
Dotted gayfeather	Liatris punctata	7	M-L	purple	2.5	F-M-C	Perennial	W-C-E	Blazing star
Engelmann’s daisy	Engelmannia peristenia	15.0	E-M-L	yellow	1.5	F-M	Perennial	W-C-E	
False boneset	Brickellia eupatorioides	0.3	M-L	white	3	M-C	Perennial	W-C-E	
False sunflower	Heliopsis helianthoides	6.0	M-L	yellow	1.5	M-C	Perennial	C-E	Smooth oxeye
Grayhead coneflower	Ratibida pinnata	2.0	M	yellow	5	M-C	Perennial	C-E	Pinnate prairie coneflower
Hairy goldenaster	Heterotheca canescens	3.0	M-L	yellow	1	C	Perennial	C-E	Hoary false golden aster
Illinois bundleflower	Desmanthus illinoensis	10.0	E-M	white	3	F-M-C	Perennial	W-C-E	
Indian blanketflower	Gaillardia pulchella	4.0	E-M-L	red	2	F-M-C	Annual	W-C-E	Firewheel
Lance-leaf coreopsis	Coreopsis lanceolata	4.0	E-M	yellow	2	F-M	Perennial	E	Lance-leaf tickseed
Lead plant	Amorpha canescens	5.0	M	purple	3	M-C	Perennial	W-C-E	
Many-flower scurfpea	Psoralidium tenuiflorum	1	M	purple	3	M-C	Perennial	W-C-E	Slim-flower scurf pea
Maximilian sunflower*	Helianthus maximilianii	5.0	M-L	yellow	9	F-M-C	Perennial	W-C-E	

Common Name	Scientific Name	Full Seeding pls/lb/ac	Bloom Period Early, Mid, Late	Flower Color	Mature Height (Feet)	Soils: Fine Medium Course	Annual, Perennial, or Biennial	Zones: West, Central, East	Notes:
Missouri goldenrod	Solidago missouriensis	0.5	M-L	yellow	3	M-C	Perennial	W-C-E	
Missouri evening primrose	Oenothera macro icarpa	10.0	E-M	yellow	1.5	C	Perennial	E	
New England aster	Symphyotrichum novae-angliae	0.7	L	purple	6	F-M	Perennial	E	
Pale purple coneflower	Echinacea pallida	8.0	E-M	purple	3	F-M-C	Perennial	E	
Pitcher sage	Salvia azurea	3.0	M-L	blue	5	F-M	Perennial	W-C-E	
Plains coreopsis	Coreopsis tinctoria	0.3	M-L	yellow	4	F-M	Annual	W-C-E	Golden tickseed
Plains sunflower	Helianthus petiolaris	10.0	M-L	yellow	5	F-M-C	Annual	W-C-E	Prairie sunflower
Prairie sagewort	Artemisia frigida	0.2	M-L	white	2	F-M-C	Perennial	C-E	
Purple prairie-clover	Dalea purpurea	3.0	M	purple	3	F-M-C	Perennial	W-C-E	Violet prairie-clover
Roundhead lespedeza	Lespedeza capitata	5.0	M-L	white	2.6	M-C	Perennial	W-C-E	
Prairie wildrose	Rosa arkansana	22.0	E-M	pink	3	M-C	Perennial	C-E	
Scarlet globemallow	Sphaeralcea coccinea	2.0	M-L	orange	1	M-C	Perennial	C-E	
Shell leaf penstemon	Penstemon grandiflorus	3.0	E-M	purple	4	M-C	Perennial	C-E	Large beardtongue
Showy partridge pea	Chamaecrista fasciculata	14.0	M-L	yellow	4	M-C	Annual	W-C-E	
Slender lespedeza	Lespedeza virginica	6.0	E-M-L	pink-purple	2.5	M-C	Perennial	E	Slender bushclover
Stiff goldenrod	Oligoneuron rigidum	0.9	M-L	yellow	3.5	M-C	Perennial	C-E	Solidago rigida
Stiff sunflower	Helianthus pauciflorus	1	M-L	yellow	5	M-C	Perennial	C-E	
Swamp milkweed	Asclepias incarnata	6.0	M	purple	5	F-M	Perennial	C-E	
Tansyaster	Machaeranthera pinnatifida	2	M-L	purple	2	M	Perennial	E	Tanseyleaf
Thickspike gayfeather	Liatris pycnostachya	7.0	M-L	purple	3.5	F-M-C	Perennial	E	Prairie Blazing Star
Upright prairie coneflower	Ratibida columnifera	1.0	M-L	yellow	3	F-M-C	Perennial	W-C-E	Mexican hat Prairie coneflower
Virginia tephrosia	Tephrosia virginiana	22	M	pink	2	M-C	Perennial	C-E	Goat’s rue
Western yarrow	Achillea millefolium	0.3	M-L	white	3	M	Perennial	W-C-E	
White heath aster	Chaetopappa ericoides	.4	E-M	white	1	M-C	Perennial	W-C-E	

Common Name	Scientific Name	Full Seeding pls/lb/ac	Bloom Period Early Mid Late	Flower Color	Mature Height (Feet)	Soils: Fine Medium Course	Annual, Perennial, or Biennial	Zones: West, Central, East	Notes:
White prairie-clover	Dalea candida	3.0	M	white	3	M-C	Perennial	C-E	
White sage	Artemisia ludoviciana	0.2	M-L	white	3	M-C	Perennial	W-C-E	
Wild bergamot	Monarda fistulosa	0.7	M	purple	4	F-M	Perennial	C-E	Beebalm
Introduced Legumes									
Alfafa	Medicago sativa	4.0	E-M-L	yellow	2	F-M	Perennial	W-C-E	Grazing alfalfa Yellow alfalfa
Black medick	Medicago lupulina	3.0	E-M-L	yellow	2	F-M	Perennial	W-C-E	
Bird’s-foot trefoil	Lotus corniculatus	2.0	E-M-L	yellow	2	F-M-C	Perennial	E	
Ladino clover	Trifolium repens	1.0	E-M-L	white	0.5	F-M	Perennial	C-E	White clover, Dutch clover
Red clover	Trifolium pratense	3.0	E-M-L	red	2	F-M-C	Perennial	C-E	
Yellow sweetclover	Melilotus officinalis	3.0	E-M-L	yellow	7	FMC	Bi-Annual	W-C-E	
White sweetclover	Melilotus alba	3.0	E-M-L	white	7	F-M-C	Bi-Annual	W-C-E	
Korean lespedeza	Kummerowia stipulacea	4.0	M-L	purple	1.5	F-M-C	Annual	E	Korean clover

Limit introduced legumes individually to 10 percent of the mix. Limit introduced legumes collectively to 20 percent of the mix.
To increase diversity it is recommended that no one native forb/legume exceed 10 percent of the mix.
*Limited to 5 percent of the seed mixture.

Appendix: Additional Information

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

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

Web sites

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

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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