DNR Pollinator Best Management Practices and Habitat Restoration Guidelines

Minnesota DNR's 5.5 million acres of land encompass a wide diversity of pollinator habitat.

Introduction

Executive Summary

This document provides best management practices (BMPs) for restoring and enhancing habitat for native insect pollinators (bees, butterflies, moths, flies, etc.) on Minnesota Department of Natural Resources-managed lands and on state-funded prairie restoration projects.

These lands are a major source of pollinator habitat in the state and include multiple habitat types. Restoration projects on DNR-managed lands are typically designed to meet specific objectives, such as providing nesting cover for upland game birds or replicating appropriate native plant communities (NPCs) previously found on the site. Enhancing restoration activities to benefit native pollinators can be done in ways that meet multiple objectives.

To have diverse, abundant, and productive pollinator populations in Minnesota, land managers must do two things. First, they must ensure we are managing existing and newly restored acres to best benefit habitat. Second, they must add habitat through restoration projects across the landscape.

When selecting species to plant, managers should use a suite of species that bloom across the entire growing season so multiple foraging resources are available for pollinators. Consider host plants for caterpillars and nesting materials for bees. Guidelines such as Operational Order 124 (Plant Material Standards for Native Plant Community Restoration), do not recommend planting non-native or invasive species to enhance pollinator habitat on DNR lands.

While this document targets native plant communities, it does not mandate specific species or seed mixes to use in a restoration. These guidelines don't dictate management on sites such as parking lots, around buildings, other facility-oriented lands or farmed fields. We want to provide land managers with information on how to augment native plant community practices to comply with state law covering pollinator habitat. For the latest in pollinator resources visit: http://www.dnr.state.mn.us/pollinator_resources/index.html

Law requires the DNR to develop and use pollinator BMPs and restoration guidelines.

Legislation

Minnesota Statutes, Chapter 84.973 POLLINATOR HABITAT PROGRAM was created in 2013 directing the DNR to establish pollinator best management practices and habitat restoration guidelines:

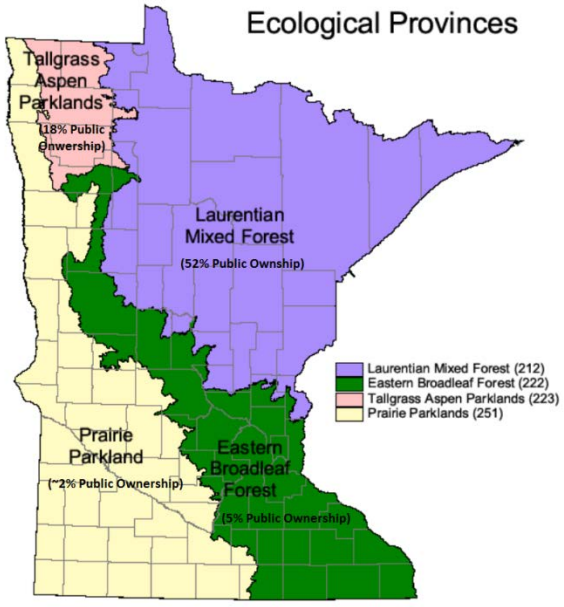
(a) The commissioner shall develop *best management practices* and *habitat restoration guidelines* for pollinator habitat enhancement. Best management practices and guidelines developed under this section must be used for all habitat enhancement or restoration of *lands under the commissioner's control.*

(b) *Prairie restorations* conducted on *state lands or with state funds* must include an *appropriate diversity of native species* selected to provide habitat for pollinators throughout the growing season.

DNR Lands and Mission

The DNR manages 5.5 million acres, about 10 percent of the state. In Minnesota, 25 percent of the land is publicly owned, including federal, state and county lands. These public lands are unevenly distributed throughout the state.

While these best practices apply to all DNR lands, because the DNR and other conservation or nongovernment organizations (NGOs) own and manage a small percentage of the land in the prairie parkland, and because pollinators of greatest concern inhabit this prairie parkland, these practices focus on the prairie region. This area is in the greatest need of habitat reservoirs on an otherwise fragmented landscape.



Land ownership by public agencies differs greatly between ecological provinces.

Natural areas provide three important functions for pollinator communities (Black et al. 2007). Natural areas:

1. Serve as a source from which pollinators can travel to pollinate agricultural crops.
2. Act as refugia (undisturbed land) from which native pollinators can recolonize agricultural areas impacted by pesticide applications, tilling, and other farming practices.
3. Serve as habitat for native pollinators of nonagricultural plants.

Bee Hives - All DNR land management divisions provide habitat for native pollinating insects. Each division has slightly different goals for the land's purpose and many units restrict activities on the property. For that reason, at this time, no DNR fee title property can accommodate private honeybee hives. On DNR easement property, placement of hives will depend upon the easement language. However, a beekeeper can place hives on private lands adjacent to DNR properties with permission from the private landowner. In general, bee hives or other personal property or business venture not providing a service to the DNR or not being used as management tools are prohibited on state lands. Consult division rules and policies for details.

Pollinators, Habitat and Population Decline

Pollinators are any animal species that pollinate flowering plants. In Minnesota, this is almost exclusively insects. Although pollinators are diverse and have a wide range of habitat, generally they need adult food sources (pollen and nectar from flowers), nesting sites, overwintering sites and larval habitat. An understanding of the features that provide these resources is essential to enhancing and restoring pollinator habitat.

Recently, there have been many reports of significant declines in populations of both native pollinating insects and managed honeybee colonies (National Research Council 2006). Numerous causes of pollinator declines have been identified, including: loss of habitat, poor diet due to limited diversity and abundance of floral resources (nectar and pollen), parasites, bacterial and viral infections, and pesticides (Black et al. 2007), as well as interactions between all of the above. The neonicotinoid class of pesticides has faced especially close scrutiny.

Minnesota has approximately 350-400 species of bees.

Within the United States and Canada alone, there are about 4,000 species of bees (Minnesota has about 350-400 species), 760 species of butterflies (Minnesota, approximately 146), 10,470 species of moths (Minnesota, about 2,000-2,500), and numerous other species of beetles, flies and ants.

"Weed laws" often dictate that DNR managers spray herbicides to control invasive species. Even when spot spraying patches instead of broadcast spraying, herbicides inevitably impact some of the native plants and pollinators managers are trying to encourage. In other cases, roadsides along DNR lands are mowed or hayed at times that may hurt pollinators and other wildlife. More communication between the natural resource community, weed inspectors, road authorities and others would help determine how best to address competing goals of providing wildlife or pollinator habitat, or both, and road maintenance while controlling invasive species.

DNR Pollinator Best Management Practices

Most of the DNR's habitat management practices promote diverse native pollinator communities. So even though it hasn't been the explicit goal, DNR lands already benefit pollinators. There are three broad management areas that could directly or indirectly impact pollinators. What follows is a discussion of best management practices to minimize negative impacts for pollinators and accentuate positive effects. When multiple management activities occur on one site, cumulative activities should not impact more than half to two-thirds of the site per year to allow for pollinator refugia.

Not all habitats are equal. Each pollinator species has different habitat requirements. We cannot manage one area or unit for the greatest benefit of all species all the time. Any management activity has the potential to hurt some species and help others. Fire, haying, or grazing, for example, may impact some habitats or populations, make habitat temporarily unavailable for pollinators, or remove some from the population. These activities are necessary for the long-term diversity and productivity of the ecosystem. We should strive to provide habitat for all pollinator species across the larger landscape each year.

For burning, the BMPs encourage leaving refuges. This can be done by creating smaller burn units, patch burning, and allowing skips (try to burn no more than half to two-thirds of a habitat type). Also, retain important habitat and extend intervals when possible.

I. Grassland Management

Prescribed Fire

Insects may winter above or below ground as eggs, larvae, pupae, or adults, depending on the species. Burning can hurt species that overwinter above ground in vegetation or are at an immobile life stage (eggs, larvae, pupae) during the typical March through May fire season. About 30 percent of bee species nest in cavities such as hollow or pithy plant stems, or tunnels in wood created by boring beetles. Queen bumblebees, including two imperiled species found in Minnesota, nest in grass thatch. Other pollinator species overwinter in grass thatch or leaf litter. Grass fires are generally fast moving and don't last long. Research from grassland habitats in other parts of the country suggests insects below ground during a fire seldom die as a direct result of the fire. The flush of flowering plants after the burn will benefit all pollinating insects. Keep in mind, burning all of one habitat type could extirpate fire-sensitive species from a site.

Specific recommendations for prescribed fire include:

- Fire refugia (unburned areas) play an important role in invertebrate conservation. Avoid burning more than half to two-thirds of a habitat type in the same year while also providing for two consecutive years of unburned refugia on a site for pollinator life cycles to be completed. Refugia can be established in a number of ways such as: creation of burn units within larger management units, and using the burn prescription to create internal refugia. Intentionally leave "skips" or unburned areas within the burn unit; they provide natural refugia.
- Land managers should ensure that all known locations of rare insects within a unit (park, scientific and natural areas, wildlife management areas) are not burned in the same year. It is important to consider how prescribed fire may impact the life cycle of those species.
- When selecting refugia for pollinators, land managers should consider:
    - If there are plant species that are known overwintering or egg-laying sites, include areas with these species within the refugia.
    - Within a management unit, ensure that refugia occur within the variety of "habitat types" in the unit. (For example, if a unit consists of wet and dry prairies, each prairie type should have some refugia.) When managing remnant habitats, ensure that some portion (at least a third) remains unburned for two consecutive years at all time. This may mean subdividing into multiple units or providing for one-third refugia each time the remnant is burned.
    - When management units include both remnant and restored habitats, ensure that refugia are created in both.
    - When planning for refugia, managers can look beyond the boundaries of the unit since adjacent properties may serve as adequate refugia.

- Intervals between fires are important to allow invertebrate populations to recover. If the composition of invertebrate species on the site is known, use recommendations from scientific literature to help determine fire return intervals. When the species composition is unknown consider these general recommendations from the literature:
    - A variety of studies suggest that three to 10 years between prairie fires provides adequate time for recovery of pollinator populations, assuming adequate refugia and adjacent populations (Black et al. 2007).
    - Allowing four to five years to elapse without fire (i.e., five-to-six-year rotation) may benefit some groups or species (Wallner et al. 2012).
    - In many cases, more frequent fire intervals can help control woody vegetation or invasive species. Managers cannot develop burn plans based solely on pollinator populations, but should incorporate these considerations when possible.
    - When possible, managers should vary the season when burns are conducted to prevent repeated impact to the same species in the same location.

Invasive Species Control and Pesticide Use

The DNR will continue to manage invasive species and practice IPM when using all pesticides (Op Order 59). Ensure applicators recognize target species target species and use proper chemicals.

Herbicides are the most commonly used pesticide on DNR land. They are primarily used to control invasive plant species or to prepare a site for restoration. Herbicides aren't usually a direct problem for pollinators although some herbicides can be. Herbicides can remove floral resources, host plants, and nesting habitat. When using pesticides, be sure to read all labeling, use proper PPE, and adhere to Operational Order 59 to minimize risks to both applicator and the environment.

The DNR uses insecticides minimally where necessary – mainly on wasp nests in high-use areas around buildings. When insecticides must be used, integrated pest management practices and label specifications should be strictly observed.

Specific recommendations for invasive species control include:

- Invasive plant species should be controlled, even if they serve as a pollen or nectar source.
- Standard invasive species best management practices (see DNR Operational Order 113, Invasive Species and applicable division guidelines) will continue to be a priority.
- Alternatively, spot mowing of invasive plant species two to three times a summer can prevent seed production and slow the spread of the species.
- Select spot treatments over broadcast applications whenever possible to minimize potential impact to pollinators and associated nectar or host plants.
- Ensure that field crews recognize target species to avoid adverse effects to nontarget native species.
- Insecticides and herbicides should be selected to be the most target-specific and applied on the smallest area practical to meet management objectives (see DNR Operational Order 59, Pesticides and Pest Control).
- Avoid neonicotinoid insecticides and other insecticides that are highly toxic to pollinators. Avoid plant materials that have been treated with neonicotinoid insecticides. Labeling guidelines make this challenging. Examples of neonicotinoids that may be used as seed dressing, soil drench, granules, injection or sprays include: imidacloprid, clothianidin, thiamethoxam, dinotefuran and acetamiprid.
- Avoid pesticide application if wind speeds exceed 10 mph.

- In most cases, reduce the spread of the invasive plants by eliminating outlying populations first and then working toward the center of the infestation.
- Spray in early morning or evening when bees and other pollinators are less active.
- Choose bio-control over pesticides if available.

Mowing, Haying and Native Seed Harvest

Managers should recognize that mowing or haying native prairie, established prairie, and recently planted restorations will have different effects on each of these plant communities. Significantly more research into the effects on plant and invertebrate communities is needed.

Key BMPs for mowing include: providing refugia, mowing after mid-September, spot mowing for invasive species and partnering with road authorities.

Normally managers are encouraged to "mix up" the management at a site, but mowing or haying the same area every year may encourage an early spring plant community. This assumes only a small percentage of an area would receive this treatment. Mowing the entire area can abruptly remove pollinator foraging resources, overwintering habitat (Hatfield et al. 2012), and host plant vegetation (Johst et al. 2006). Each pollinator species uses different parts of the habitat or vegetation at different times of the year. Mowing or haying at any time of the year will benefit some species and impact others.

Specific recommendations for mowing and haying include:

- It's important to avoid mowing the whole area at once. It is better to mow different areas at different times to avoid impacting the entire population of any species on that unit. Leave one-third to half of the habitat type as refugia–areas left undisturbed–with no mowing or haying if possible.
- If mowing the entire unit is necessary to meet other management goals, subdivide the unit into at least two units and mow the areas several weeks apart so that the whole unit isn't affected at once. Consider seasonality, plant species and pollinators when identifying the refugia similar to prescribed fire practices.
- When mowing to control invasive species or encroachment of woody species, focus on patches of invasives or woody species, leaving the rest of the habitat intact.
- Mowing (cutting) should be as high as possible to meet the management goals and make the most of the nesting and overwintering habitat left on site.

Conservation Grazing

Well-managed cattle grazing along with controlled burns, invasive species control and rest is gaining greater acceptance as a tool for managing grassland habitats in Minnesota. Grazing is particularly useful for altering vegetation height and providing short grass habitat required by several prairie obligate animal species. Grazers primarily target grasses (Plumb and Dodd, 1993), so forbs don't have to compete with these grasses. Several studies demonstrate increases in plant species diversity and forb abundance in upland prairies in portions of the tallgrass prairie region (Hickman et al. 2004, Symstad et al. 2010). Properly managed grazing should have limited negative impact on overall pollen and nectar resources. Some pollinator-preferred plant species such as purple coneflower respond well to periodic grazing. Grazing can create patchiness in the fuels that carry prescribed fire, increasing the patchiness of fires and the unburned refugia that enhance the recolonization of fire-sensitive invertebrates. Short-term grazing targeted to suppress smooth brome may promote greater expression of native forbs in portions of a site overrun by brome.

When grazing leave refugia, limit duration and have a diversity of stubble heights.

Like any management tool, grazing has some potential negative consequences for insects. An increase in plant species diversity as a result of grazing management is not necessarily the same as an increase in the abundance or quality of nectar resources. Many species that increase with grazing have little value for pollinators (e.g., prairie ragweed, *Ambrosia psilostachya*, wooly plantain, *Plantago patagonica*, fringed sage, *Artemisia frigida*—all wind pollinated). Though cattle consume mostly grasses, they seek palatable forbs more than bison (Plumb and Dodd, 1994, Helzer and Steuter, 2005) and selectively target some nectar-producing forb species particularly attractive to them (Curtis, 1959). Some cattle, for example, will target several native milkweed species that are high-quality nectar resources and also host plants for the monarch butterfly. Though episodes of grazing may increase the density of flowers in some forbs for a couple of subsequent years of little or no grazing, flower density can be greatly reduced the year of the grazing (Moranz et al. 2014). Some imperiled butterflies and moths such as Dakota skipper and Poweshiek skipperling (USFWS, 2013) depend upon standing stems and foliage of warm season grasses for larval feeding and shelter. Grazing intensity that appreciably removes this resource can be bad for the insects. Trampling may also be a problem for them. Grazing can increase problem species such as leafy spurge or invasive thistles, which has prompted some managers to use herbicides to the point of eliminating native forbs (Spomer, 2004).

The DNR's management direction toward conservation grazing as a means to enhance wildlife habitat should be consistent with pollinator conservation.

Specific recommendations for grazing include:

- Limit the duration and intensity of grazing on sites so that residual cover is left after livestock are removed. However, there will be times when the grass is grazed shorter to meet specific management objectives at that site.
- Manage grazing so the more sensitive plant species that are part of the prairie do not decline.
- Monitor grazing to create a range of habitat structures (height of plants) to create diversity that is generally beneficial to forbs and pollinators as well as other wildlife.
- Where heavier grazing of a site is called for, leave one-third to half of the important habitats ungrazed as refugia for pollinators.
- On larger units, managers can set up grazing paddocks or regimes to rotate grazers within the site to retain some nectar and host plants. Alter the grazing cycle so sites aren't grazed during the same time each year.
- Insecticides used for parasite control in cattle are systemic and can benefit insects as well as pests. The DNR worked with the state veterinarian, Board of Animal Health, and cattle producers to set up parasite control guidelines that are sensitive to native insects and has developed a list of acceptable products and practices that can be found on the Minnesota Pollinator Resources webpage.

Farming Practices

Although the DNR uses native vegetation as much as possible, policy allows the use of cropland management to meet specific objectives, including habitat restoration, habitat management, supplemental food for wildlife, and attracting wildlife for viewing and photography. Four farming practices can impact pollinators: plant selection, crop diversity and rotation, tillage and weed control and insecticides.

Farming activities were not included in these guidelines because farmed fields are not considered a native plant community. As the guidelines were being drafted, it was apparent that farming activities are both a tool used as a means to restore native plant communities and as a tool to manage for wildlife and wildlife-related recreation. Due to the profound impact farming practices potentially pose to pollinators, farming practices will be reviewed and addressed in a follow-up document.

II. Forest Management

The Minnesota Forest Resources Council's site-level forest management guidelines have been designed to protect wildlife populations associated with forested plant communities during the course of vegetation management activities.
(See http://mn.gov/frc/documents/council/site-level/MFRC_Revised%20Forest%20Management%20Guidelines%20(2012).pdf) The guidelines define wildlife as "all forms of life that are wild, including plants, animals and microorganisms." The guidelines have been designed to minimize the risk to habitat

wildlife populations depend on, during forest management activities. In some cases these activities are designed specifically to enhance wildlife habitat. These guidelines also apply to pollinators.

Forest management practices will indirectly benefit pollinator species by maintaining functional forest ecosystem components. Forest management activities can potentially enhance or remove habitat for a variety of wildlife, including pollinator insects, by altering the composition of vegetation in a given area. As more information about pollinator use of forest environments becomes known, forest managers' ability to design activities to achieve more specific habitat goals, including pollinator habitat enhancements, will increase.

Forest management practices should include providing refugia, designing treatment and harvest to avoid impact to spring nectar producers, retaining nesting structure, and encouraging site and landscape diversity.

The Minnesota DNR manages forested native pollinator communities for a range of native species through management activities and allowing for natural processes that result in a range of conditions across the landscape. While new information on pollinator use of forest habitats will be helpful for determining potential habitat enhancements forest managers may influence, the DNR intends to manage native species largely within plant communities in which they have historically existed. Introducing flowering plants (for pollinator resources) into forested plant communities where they have not historically been, whether these are non-native and invasive species or species native to the state but planted outside their geographic range, has the potential to disrupt the natural ecology of that community, and is not an acceptable strategy. Knowledge of the interrelationships of pollinating insects and forest plants is limited.

Under law, state lands are managed for multiple uses; consequently, it's not practical to design forest management practices exclusively for pollinators. Using techniques designed to lessen negative impacts from management activities will help sustain forest-dependent pollinators.

Specific recommendations for forest management activities include:

- Use pesticides judiciously. Avoid broadcast spraying when other effective means of control are available; encourage the use of spot treatments.
- When managing for legacy elements (patches within a treatment area that retain native plants), select areas to include as many plants as possible that produce pollen and nectar.
- Strive to minimize impact to spring ephemerals.

- Maintain a variety of plant communities and conditions across the landscape.
- When designing timber harvest, retain standing dead and downed dead logs. These can serve as nesting habitat for bees, as well as feeding habitat for beetle and hoverfly pollinators whose larvae are saproxylic (dependent on decaying wood).
- Design forest management activities to protect the soil (and thereby protect underground plant structures that regenerate flowering plants and protect ground nesting pollinators).
- When planting trees or shrubs consider the floral resources for added spring and early summer blooming resources. Consult the native plant community pollinator tables (http://files.dnr.state.mn.us/natural_resources/npc/pollinator_booklet_single.pdf) for specific species.

III. Riparian and Shoreline Management

Riparian areas can provide valuable habitat and travel corridors for pollinators, linking other foraging and nesting habitat. Riparian areas provide a unique opportunity to supply early-flowering willow and in dry areas, late flowering native forbs. Many DNR properties contain rivers, streams, wetlands, lakes, bogs and other waterways. Erosion and water quality concerns have prompted stricter management guidelines for these areas than other upland property. Many guidelines for grassland management and forest management still apply. However, the natural species mix will be different. Consider the NPC adjacent to the site when selecting species to plant in a riparian area.

Specific recommendations for stream bank and shoreline activities include:

- Plants attractive to pollinators can be used along waterways, but planting should not interfere with the hydraulic function of the waterway and the primary objective of stabilizing the bank against erosion.
- To enhance habitat for native bee communities, increase the diversity and abundance of flowering plants growing on a site and add nesting habitat. Consider pollinator needs when choosing native tree species for riparian forest buffers. For example, willow, dogwood, and goldenrod benefit pollinators.
- Seed mixes can include native legumes or other forbs that provide pollen and nectar for native bees. These sites may be able to support flowering forbs with higher water requirements and provide bloom later in the summer. Consult the native plant community pollinator tables for specific species.
- Maximizing plant diversity along riparian corridors will result in more pollinators and also other terrestrial insects that act as forage for fish.

Habitat Restoration Guidelines-Providing New Habitat

Restoration efforts will be guided by native plant communities.

Native plant community restoration adds to the resources required for pollinator populations to thrive. The following restoration guidelines primarily focus on the state's prairie region where native plant communities are scarce and may be limiting factors in pollinator populations. In the prairie region, restoration usually means starting with bare soil, crop stubble, and planting seeds of native grasses and forbs. "Restoration" in this context means "starting from scratch" as opposed to forestry practices where seed banks and roots are often already present after a timber harvest. In circumstances where forest restoration occurs by these standards, similar guidelines apply.

Restorations rarely if ever have the full complement of species found in remnant native plant communities. Specifically, early blooming species are often absent from standard mixes, especially when seed sources are harvested by combine. If seed mixes are not custom assembled, early blooming species can be hard to find, more costly or difficult to establish. Conversely, late season blooming species, especially members of the aster or sunflower and legume family, are commonly used in seed mixes.

Pollinator species fall on a spectrum between generalist feeders and specialists dependent on a plant family or species. By increasing restoration diversity and paying special attention to plants specifically associated with a pollinator species, the DNR can support the intricate relationships between native pollinators and native vegetation that keep both communities healthy.

General recommendations for habitat restorations include:

- Restoration planning, especially species selection, should be guided by knowledge of the expected native plant community on the site and any natural resource surveys (plants, invertebrates, soils, hydrology) that might inform the effort.
- Refer to the native plant community pollinator tables for specific host species.
- Plant selection should include those species that support endangered, threatened, special concern or rare-pollinating species. These pollinating invertebrate species often have specific host plant species.

- Current research indicates that it is difficult to successfully interseed forbs into dense well established grass. Alternatives include extensive disking to weaken the grass and expose soil or to consider establishing 5-10 acre pollinator plots. Minimum size and number of plots needed to impact pollinators remains unknown and is likely dependent upon the site.
- When buying seed mixes, live plants, shrubs or trees from a native plant producer or a garden center, make sure that the plant material will not hurt pollinators. Avoid plant materials with seed, plant or soil sources treated with neonicotinoid insecticides. Labeling guidelines can make this challenging. Examples of neonicotinoids that may be used as seed dressing, soil drench, granules, injection or sprays include: imidacloprid, clothianidin, thiamethoxam, dinotefuran and acetamiprid.
- These guidelines recognize that management activities for restoration sites often include actions such as mowing, prescribed fire, herbicide applications and even farming, applied in a manner that may seem inconsistent with pollinator conservation in the short term but may be necessary to establish the plant community and keep it healthy long term.

Landscape Level Considerations
Habitat complexes and corridors provide natural passageways for all wildlife, including pollinators. If managers consider the landscape in which the restoration exists, they can optimize the location of pollinator habitat enhancements. Pay attention to how a particular restoration contributes to landscape level planning.

Specific recommendations for habitat restorations include:
- Sites that are adjacent to existing remnant plant communities, next to known pollinator areas, or connected to pollinator areas by suitable habitat corridors are ideal locations for restoration. Existing populations of pollinators may more easily colonize new habitat in these areas. Remnant prairie protection through prairie bank and other programs is vital to providing pollinator habitat.
- Pay attention to past and present insecticide use on and adjacent to the site so that appropriate mitigation can be applied.
- Consider the distance between available foraging, nesting and water resources. Keep in mind the flight distance of native bees ranges from as little as 200 feet to a mile or more.

Site Level Considerations
These guidelines minimally require nine pollinator-supporting species, three each with blooming periods early, middle, and late summer, on at least 10 percent of the site (Refer to the pollinator tables). Consider this a minimum. Strive to make the most of the diversity of seed mixes for species appropriate to the site but keep economic considerations in mind. Many of the more desirable species, especially those spring blooming species, can be expensive. Rely on your best judgment in the trade-off between increasing the number of species and buying more inexpensive seed and increasing the density of forbs on the site.

When planting some of the more expensive species, take extra care to consider micro-sites for planting. For example, planting pasqueflower seed along a wetland margin will be challenging. Also note that many of the spring species are short and often do best with a haying or grazing regime that removes much of the late summer thatch and allows the species to emerge early. Take long-term management into consideration when planting some of these species. Remember that restorations in the prairie region are all quite different, which also adds to landscape level diversity.

Site Prep for Restoration or Enhancement

Site preparation for restoring new pollinator habitat should begin by assessing past practices on the acres being restored and the potential for pesticide exposure from adjacent lands.

Consider the landscape context in which the native plant community restoration exists.

Specific recommendations for site prep include:

- Place pollinator habitat enhancement plantings on soils free of persistent pesticides harmful to pollinators, such as insecticides known as neonicotinoids. Systemic insecticides, like the neonicotinoids, can be stored in the soil and absorbed by new plantings and transferred to pollinators that forage on them (see Hopwood et al. 2012 for review). Since it often takes several years for many native forbs to become established and bloom, this may not be a problem.
- Emphasize pollinator planting efforts away from adjoining lands where there is potential for pesticide drift harmful to pollinators. When appropriate with other objectives, identify areas within the restoration where increased diversity consistent with pollinator habitat needs could be emphasized. Specific recommendations for these "patches" can be found in the Foraging Habitat section.

Enhancing Diversity in Existing Grasslands

Many consider restoration as starting from bare soil and soybean stubble. There may also be an interest in enhancing existing grasslands. Many conservation acres under fee title were planted decades ago with brome or low diversity native grasses. On private lands there are also many acres, such as early CRP mixes, that have a low diversity of native forbs.

Interseeding into existing grass has shown limited success in the literature and should be approached with caution. Even in native prairie, almost no plants are established from seeds (Benson and Hartnett 2006) except on disturbed areas such as gopher mounds

(Rogers and Hartnett, 2001). Competition with tall robust grasses makes it difficult for forbs to become established from seed.

Specific recommendations for enhancing diversity in existing grasslands include:

- Chemical treatment (Roundup®) of the vegetation before planting. To get good seed-soil contact, burn the site in the fall before seeding.
- Disking the soil both weakens established plants and creates the bare soil patches seeds need to become established.
- Grazing an area interseeded with forbs can also reduce grass competition and aid in forb establishment (Martin and Wilsey, 2006).

Seed Selection and Planting – Foraging Habitat & Nesting Habitat

Foraging Habitat

Diversity is a critical factor in the design of pollinator foraging habitat. Flowering plants should be available throughout the entire growing season to provide protein and carbohydrates to sustain pollinator populations. Include a diversity of plants with different flower colors, sizes, and shapes as well as varying plant heights and growth patterns to encourage the greatest numbers and diverse mix of pollinators. Also, research shows that the higher the density of flowering plants, the more attractive the area is to pollinating insects. It is important to insure that species selected are within their natural range and that Op Order 124, Plant Material Standards for Native Plant Community Restoration, is followed. Use nearby or similar reference communities or the native plant community pollinator tables to help in species selection.

Specific recommendations for foraging habitat include:

- Within the species associated with the native plant community, include a diverse mix of native flowers to attract a broad range of pollinators. Bees typically visit flowers that are purple, violet, yellow, white and blue. Butterflies visit a similarly wide range of colors, including red. Flies are primarily attracted to white and yellow flowers.
- Strive for at least three different pollinator supporting species within each of the three blooming periods (early, mid or late season). In addition to herbaceous plants, flowering shrubs can be an important source of pollen and nectar for pollinators, particularly early in the spring. Refer to the pollinator tables for species recommendations appropriate in your area. Ideally, a native plant community approach should be taken and appropriate species mixes

Strive for at least three native flowers blooming in spring, summer and fall. The more diversity, the better.

should be planted on an entire site. In some cases, it may be necessary to take a "patch" approach. In this situation, at least 10 percent of the site should contain the required pollinator supporting species.

- Plant diverse grasses; don't rely on just big bluestem and Indiangrass. Include shorter grasses (side-oats grama), bunchgrasses (little bluestem), and native cool-season grasses if the soils are appropriate with the plant community. Short statured grasses will decrease light competition for flowering species. Refer to the pollinator tables for specific species recommendations.
- Increase the seed rate for flowering species and decrease the seed rate for grass species.

Nesting Habitat

Pollinating insects nest in a variety of habitats; soil, the bases of bunch grasses, the hollow stems of grasses and shrubs. Make sure all of these habitats are available within the management area.

Specific recommendations for nesting habitat include:

- Plant some native bunch grasses (such as little bluestem), as opposed to primarily rhizomatous or sod grasses, that leave small patches of bare ground exposed. These grasses can also provide forage resources for the larval stages of native butterflies, as well as overwintering sites for other beneficial insects.
- When conducting management activities, leave some patches of undisturbed grass so rodents can nest and create future nesting sites for bumblebees.
- Avoid clearing or burning fallen or dead trees when consistent with other objectives, as they contain potential nesting sites for a wide range of pollinators, including cavity-nesting bees, as well as larval food sources for many species of pollinating beetles and hoverflies. These decisions will be site specific. In many prairie projects, it's often best to remove the woody material. If working in shrublands, forests, or riparian areas, some woody debris should be left on-site.

Prairie Restorations with State Funds

Section (b) of the pollinator habitat legislation states: "Prairie restorations conducted on state lands or with state funds must include an appropriate diversity of native species selected to provide habitat for pollinators throughout the growing season." This language is specific to prairie restorations only. Prairie restoration projects that use state funds include but are not limited to all Operational and Dedicated Funds, Working Lands Initiative Projects, Environment and Natural Resource Trust Fund, Outdoor Heritage Fund, Conservation Partners Legacy Grants, Aquatic Habitat Restoration Grants, Recreation Grants, Parks and Trails Legacy Grants, and Local Trail Connection Grants. These are subject to the restoration guidelines in this document.

Contract Language

DNR grant agreements and contract work to accomplish habitat restoration or enhancement on DNR lands or prairie restorations using state funds are also subject to the best management practices and guidelines in this document. **The following standard language should be included in grants and contracts for all habitat enhancements or restoration work**:

Conservation partners Legacy projects and working lands projects must use diverse native species to provide pollinator habitat.

Specific Pollinator Best Management Practices for Grants and Contracts

Habitat Restoration Guidelines:

- Place pollinator habitat enhancement plantings on soil free of persistent pesticides harmful to pollinators.
- Pay attention to past and present insecticide use on and adjacent to the site so that appropriate mitigation can be applied.
- Emphasize pollinator planting efforts away from adjoining lands where there is potential for pesticide drift harmful to pollinators.
- Avoid clearing or burning fallen or dead trees when consistent with other objectives, as they contain potential nesting sites.
- Species selection should be guided by knowledge of the expected native plant communities on the site and any natural resource surveys (plants, invertebrates, soils, hydrology) that might inform the restoration effort.
- Refer to the pollinator tables for specific host species.
- Include a diverse mix of native flowers to attract a broad range of pollinators. Strive for at least three different pollinator supporting species within each of the three blooming periods (early, mid or late season).
- Plant some native bunch grasses (such as little bluestem).
- Plant selection should include plant species that support endangered, threatened, special concern or rare-pollinating species.
- Avoid plant materials with seed, plant or soil sources that have been treated with neonicotinoid insecticides.

Stream Bank and Shoreline Guidelines:

- Plants attractive to pollinators can be used along waterways, but the planting should not interfere with the hydraulic function of the waterway and the primary objective of stabilizing the bank against erosion.

- To enhance habitat for native bee communities, increase the diversity and number of flowering plants growing on a site and add nesting habitat. Consider pollinator needs when choosing trees for riparian forest buffers. For example, willow, dogwood and goldenrod benefit pollinators.
- Seed mixes can include legumes or other forbs that provide pollen and nectar for native bees. These sites may be able to support flowering forbs with higher water requirements and provide bloom later in the summer. Consult the native plant community pollinator tables for specific species.
- Maximizing plant diversity along riparian corridors will result in more pollinators and other terrestrial insects that act as forage for fish.

Prescribed Disturbance- Fire/Mowing/Haying:

- Ensure that all known locations of rare insects are not disturbed in the same year.
- Avoid impacting more than half to two-thirds of a habitat type in the same year.
- Allow 3 to 10 years rest between disturbances to provide recovery time for pollinator populations.
- Vary the season when disturbances are conducted to prevent repeated impacts to the same species in the same location.
- When selecting refugia for pollinators, consider:
    - If there are plant species that are known overwintering or egg-laying sites, include areas with these species within the refugia.
    - Within a management unit, ensure that refugia occur within the unit's variety of "habitat types." When managing remnant habitats, ensure that at least a third remains unburned for two consecutive years at all time.
    - When management units include both remnant and restored habitats, ensure that refugia are created in both.
- If disturbance to the entire area is necessary to meet other management goals, subdivide the unit into at least two units and burn or mow or hay the areas several weeks apart so the whole unit isn't affected at once.
- When controlling invasive species or encroachment of woody species, target undesirable patches, leaving the rest of the habitat intact.
- Mowing should occur as high as possible to still meet the management goals in order to make the most of nesting or overwintering habitat left on site.

Invasive species control:

- Invasive plant species should be controlled, even if they serve as a pollen or nectar source.
- Avoid neonicotinoid insecticides.
- Select spot treatments over broadcast applications.
- Choose bio-control over pesticides if available.
- Insecticides and herbicides should be selected to be the most target-specific and applied on the smallest area practical to meet management objectives.
- Ensure that crews recognize target species.
- Spray in early morning or evening when bees and other pollinators are less active.
- Avoid pesticide application if wind speeds exceed 10 mph.

- Eliminate outlying populations of invasive species first and then work towards the center of the infestation.
- Monitor pesticides for dispersal by drift, erosion or runoff.

Conservation grazing:

- Limit the duration and intensity of grazing on sites so that residual cover is left after the livestock are removed if consistent with key management objectives.
- On larger units, set up grazing paddocks or regimes to rotate grazers within the site and allow for retention of some nectar and host plants. Alter the grazing cycle so any site is not grazed during the same time each year.
- Monitor grazing to create a range of habitat structures (height of plants) to create diversity.
- Where heavier grazing of a site is called for, leave one-third to half of the important habitats ungrazed.
- Manage grazing so that the more sensitive plant species that are prairie components do not decline.
- Insecticides used for parasite control in cattle are systemic and can benefit insects as well as pests. The DNR worked with the state veterinarian, Board of Animal Health, and cattle producers to set up parasite control guidelines that are sensitive to native insects and has developed a list of acceptable products and practices that can be found on the Minnesota Pollinator Resources webpage.

Specific best management practices for forest management activities include:

- Avoid broadcast spraying of pesticides when other effective means of control are available; encourage the use of spot treatments.
- When managing for legacy elements (patches within a treatment area that retain native plant community representation), select areas to include as many plants as possible that produce pollen and nectar.
- Minimize impact to spring ephemerals.
- Maintain a variety of plant communities and conditions across the landscape.
- Retain standing dead and downed dead logs where possible to serve as nesting habitat for bees, as well as feeding habitat for beetle and hoverfly pollinators whose larvae are saproxylic.
- Design forest management activities to protect the soil (and thereby protect underground plant structures that serve to regenerate flowering plants and protect ground nesting pollinators from impact).
- When planting trees or shrubs consider floral resources for added spring and early summer blooming resources (For example, American basswood, serviceberry, and willow where ecologically appropriate).

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