ROADSIDES AS HABITAT FOR POLLINATORS: MANAGEMENT TO SUPPORT BEES AND BUTTERFLIES

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ABSTRACT

Pollination of flowering plants is an essential ecosystem service. It is estimated that 85% of flowering plants worldwide and 35% of global crop production rely on animals for pollination. Pollinators such as bees, flies, wasps, beetles, moths, and butterflies play multiple roles in food webs in addition to facilitating the reproduction of flowering plants. Fruits and seeds, the product of pollination, are an important part of the diet of many birds and mammals, and pollinators are a direct food source for other wildlife such as songbirds and even grizzly bears as well. However, research indicates that some managed and wild pollinators are in decline. Threats to pollinators affect not only pollinators themselves but also the stability of natural ecosystems and agricultural productivity.

Roadsides are known to have value as habitat for plants, as well as birds, small mammals, amphibians, reptiles, ants and beetles. Roadsides can also be a refuge for pollinators, especially in landscapes substantially altered by urbanization or agriculture. Often the only semi-natural areas remaining in heavily altered landscapes, marginal habitats like roadsides can provide pollinators with places to forage for food and to nest.

Pollinator habitat must include blooming flowers, which supply pollinators with protein-rich pollen and energy-providing nectar. Pollinators also require a place to nest or to lay their eggs. Butterflies and moths generally lay their eggs on or next to the host plant upon which their vegetation-eating caterpillars will feed. In contrast, bees create nests in which they leave food for their young. Many bee species dig subterranean nests in their preferred soil type, while other species nest above ground in plant stems or cavities in dead wood. Bumble bees nest within insulated cavities, under clumps of grass or in old rodent burrows.

Studies demonstrate that roadsides planted with native plants support more butterflies and bees than do roadsides dominated by non-native grasses and flowers. With millions of acres of land in roadsides, managing roadsides with pollinators in mind could have a significant impact on pollinator conservation. New roadside plantings should include a diversity of native wildflowers with overlapping bloom times, to provide for pollinators throughout the growing season, including key host plants for butterflies. For example, monarch butterflies, renowned for their impressive long-distance seasonal migration, rely on milkweed species only as host plants. Monarch populations have been declining over

the last fifteen years, and reduced numbers of milkweeds across the butterfly's breeding range, particularly within agricultural fields, are likely contributing to their decline. Planting milkweeds along roadsides can restore monarch breeding habitat, including along migration routes.

Roadsides can be of great benefit to pollinators. Best management practices include consideration of timing and frequency of mowing, spot spraying rather than broadcast use of herbicides, and surveys to identify existing roadside habitat that provides native plant resources for wildlife. Roadside managers can develop a management strategy that addresses safety concerns while also benefiting wildlife such as pollinators.

INTRODUCTION

Roadside verges cover more than 10 million acres of land in the United States (Forman et al. 2003). This land can offer valuable habitat because it is typically set aside from further development and because it stretches across the landscape, connecting remnant habitat patches and creating a linear refuge for wildlife. This is particularly true in agricultural regions, urban areas, and other highly modified landscapes, where roadsides may be the only semi-natural habitat remaining. With four acres of open space lost to development every minute (U.S. Forest Service 2006), roadsides are too important to be neglected in conservation planning.

Incorporating native plants into roadside management strategies will improve these areas for wildlife, but it also can promote motorist safety, improve roadside aesthetics, and may reduce maintenance costs.

The abundance and diversity of insects and other invertebrates are key building blocks of the wildlife value of a site. They are a food source for birds, mammals, and other vertebrates, and the services invertebrates provide maintain habitats on which other animals rely. One such ecosystem service is pollination, a service central to human health as well as to the health of our environment. Beetles, flies, wasps, moths and butterflies all contribute to pollination, but bees are considered to the most important group of pollinators.

Managing roadsides to support pollinators brings benefits for both local natural or semi-natural areas as well as adjacent farms. One of the key considerations is the presence of native plants. Roadsides with a rich diversity of native plants support more pollinators. By adapting roadside management strategies to include maintaining existing native plant populations or the incorporation of native plants into new roadside plantings, roadsides can be more valuable to pollinators and other wildlife that provide ecosystem services. Additionally, the use of native vegetation along roadsides is compatible with promoting motorist safety, improving roadside aesthetics, and reducing maintenance costs.

Importance of Pollinators

Plant pollination by animals is an essential ecosystem service. It is estimated that about 85% percent of the world's flowering plants depend on animals—mostly insects—for pollination (Ollerton et al. 2011). Eighty-seven of the world's 124 most commonly cultivated crops are reliant on animal pollinators, and insect-pollinated forage plants such as alfalfa and clover provide feed for livestock. Roughly thirty-five percent of global crop production is dependent on pollination by animals (Klein et al. 2006). Pollinators also sustain wildland plant communities that provide food and shelter for myriad other wildlife. As one of the most widespread and important ecosystem services in terrestrial environments, plant pollination by insects is essential to human health, global food webs, and protection of biodiversity.

Studies in multiple parts of the world have suggested that pollinator populations are

declining. In the United States, the National Research Council (2007) reported noteworthy losses of both managed and wild pollinators. Habitat loss, pesticide use, diseases, parasites, and the spread of invasive species are the major causes of pollinator decline. In Europe, parallel declines of pollinator and flowering plant diversity have been documented in both Great Britain and the Netherlands (Biesmeijer et al. 2006). Threats to pollinator communities affect not only pollinators themselves but also natural ecosystems and agricultural productivity.

In environments substantially altered by urbanization or agriculture, marginal habitats such as hedgerows, roadsides, and field edges may be especially important for the conservation of biodiversity. Often the only semi-natural areas remaining within a landscape, these areas provide pollinators with places to forage for food and nest, while also helping to link fragmented habitats.

Roadsides as Habitat

Though roadsides are not a substitute for wildlands, they do have value as habitat for birds (Adams 1984), small mammals (Camp and Best 1994), amphibians and reptiles (Way 1977), and ants and beetles (Keals and Majer 1991; Vermeulen 1993). Roadside habitats also provide refuge for pollinators. A diversity of wildflowers provides nectar or pollen for all pollinators, and grasses and forbs serve as larval hostplants for butterflies and moths. Roadsides offer nesting sites for bees, particularly ground-nesting bees because the soil is undisturbed compared to the surrounding agricultural fields (Delaplane and Mayer 2000). Roadsides also promote connectivity between habitat fragments (Forman et al. 2003). In some cases, roadsides support plant communities that can no longer be found elsewhere (Forman et al. 2003; Noordijk et al. 2009).

NATURAL HISTORY OF POLLINATORS

Although a number of insects can contribute to pollination, in this document the focus is on the habitat needs of bees and butterflies, because the natural history and habitat needs of these pollinators are better understood than those of flies, beetles, and other insect pollinators. Native bees and butterflies share the same basic life cycle –egg, larva, pupa, and adult stages—and also the same basic habitat needs: flowers on which to forage for food and somewhere to lay their eggs.

Nectar and Pollen Sources

Most flowers offer sugary nectar or nutritious pollen to attract floral visitors. When visitors to flowers feed on pollen or nectar, these visitors incidentally transfer pollen between flowers, effecting pollination. Bees are particularly effective and important pollinators because they provision nests for their offspring, so they not only feed but also gather and transport pollen. Pollinator habitat should have a diversity of flowers that bloom at different times to sustain a diverse group of pollinators throughout the growing season.

Sites for Nesting or Egg-Laying

Pollinator insects also require a place to nest or to lay their eggs. For example, butterflies and moths generally lay their eggs on or next to the plants upon which their caterpillars will eventually feed. Many butterflies are very particular about which host plants they use. Karner Blue butterfly (*Lycaeides melissa samuelis*) caterpillars can only eat lupine (*Lupinus perennis*). Other butterflies are less choosy about where to lay eggs, because their caterpillars will eat several types of plants. Caterpillars of the woodland skipper, for example, feed on many grasses, while caterpillars of the anise swallowtail have been recorded feeding on more than sixty different plants in the carrot family. Although a butterfly may carefully choose a host plant, her parental responsibilities end when she lays her eggs. Eggs and subsequent caterpillars must fend for themselves.

In contrast, bees create a nest in which they construct and supply a series of brood cells. Nearly 70 percent of bee species nest underground, digging slender tunnels off which they excavate cells for their eggs. Most other bees choose to nest in cavities, chewing into the pithy center of stems, or clearing out existing holes, in which they create a linear series of partitioned cells. Some bees need specific nest-building materials such as mud, resin, or flower petals (Linsley 1958), which they use to form the partitions. Bumble bees are social bees, and require a small insulated cavity such as an abandoned mouse nest to house their annual colony. Pollinator habitat should include a range of nesting substrates and materials to provide for the differing nesting requirements of pollinators.

NATIVE PLANTS AND ROADSIDE MANAGEMENT

While roadside management in the United States differs from state to state, the primary goals remain the same: motorist safety, noxious weed prevention, and soil stabilization. In recent years, many states have incorporated native grasses and wildflowers into road rights-of-way to achieve these objectives. In some cases, techniques that roadside managers already use can make a difference in the conservation of pollinators.

Integrated Roadside Vegetation Management (IRVM) incorporates the planting of native vegetation with site-appropriate strategies in order to achieve cost-effective and more environmentally sustainable management practices for roadside rights-of-ways. As an alternative to intensive mowing and blanket herbicide spraying of roadsides, IRVM offers several advantages for roadside management.

- Native grasses and flowers are best adapted to local growing conditions, and are able to tolerate drought or heat.
- An established diverse plant community provides the most stable cover for reducing erosion and keeping out weeds. For example, tallgrass prairie restoration can limit the invasion of noxious weeds, due to strong root development (Blumenthal et al. 2005).
- Improved weed and erosion control can reduce the need to spray herbicides and to mow, thereby reducing maintenance costs.
- Native plants are less likely to encroach on land bordering rights-of-way, a common complaint about non-natives such as crownvetch (*Securigera varia*) and

sericea lespedeza (*Lespedeza cuneata*) once planted on roadsides for soil stabilization.
- Native plant communities will reduce runoff in the spring and act as snow fences in the winter, trapping and preventing snow from blowing across roads.
- Native plantings are aesthetically pleasing, and may offer educational opportunities, as they demonstrate how the contiguous landscape once looked.
- Native plant communities support more native wildlife than non-native plant communities.

BENEFITS OF ROADSIDE PLANTINGS TO POLLINATORS

Seeding roadsides with native vegetation often increase the diversity of plants in the local area (Muguira and Thomas 1992; Forman et al. 2003) and may provide more abundant pollen and nectar sources compared to adjacent areas. In addition, the reduced need for herbicide spraying to control weeds creates havens for pollinators and other wildlife.

Nectar and Pollen Sources

Research demonstrates the benefits to pollinators of having native wildflowers on roadsides. Working in Kansas, Hopwood (2008) found bees to be twice as abundant on roadsides with native plants compared with those dominated by nonnative grass and flowers; native roadsides also supported about 35 percent more bee species. The study showed that roadsides planted with natives had higher floral diversity, and although abundance of flowers was similar between native and weedy roadsides, the native roadsides were still more attractive to bees.

Butterflies also benefit from the presence of native plants, as shown by research from North America and Europe. Ries et al. (2001) compared roadsides in Iowa that had been replanted with native prairie grasses and wildflowers with those that were grassy or weedy, and found that habitat-sensitive butterfly species such as the regal fritillary (*Speyeria idalia*) and Delaware skipper (*Anatrytone logan*) were significantly more common in prairie roadsides. In Minnesota, butterflies were most abundant in filter strips between cropland and streams that were planted with tall and dense vegetation (Reeder et al. 2005).

In Finland, the number of butterflies along roadsides was most influenced by the abundance of nectar producing plants, while moths were most abundant in areas with tall vegetation, which provided shelter (Saarinen et al. 2005). In Britain, work by Muguira and Thomas (1992) found that the number of butterfly species using roadsides was relatively high, and suggest that planting roadsides with native plants would further increase the occurrence of butterflies (Muguira and Thomas 1992).

Sites for Nesting or Egg-Laying

Many bees prefer to nest in sunny, bare patches of soil (Linsley 1958), like those found around the base of native bunch grasses such as big bluestem (*Andropogon gerardii*) and

Indiangrass (*Sorghastrum nutans*) that tend to grow in dense bundles, leaving small patches of bare ground exposed. The research in Kansas by Hopwood (2008) found that ground-nesting bees were more common in roadsides with native plantings. In contrast, roadsides with a tight sod of brome brome or other nonnative cool season grasses had fewer ground-nesting bees. Some bumble bees nest underneath grass clumps (Svennson et al. 2000), or under the thatch of bunch grasses (Hatfield et al. 2012). Researchers in Northwestern Europe found 11 species of bees nesting in the ground in roadside verges (Schaffers et al. 2012). In Britain, roadsides have been identified as breeding habitat for eight of the 17 species of bumble bees, and 25 of the 60 species of butterflies (Way 1997).

Landscape Linkages

Given their linear structure, roadsides may serve as corridors for pollinators and other wildlife. In Iowa, Ries et al. (2001) found that habitat-sensitive butterflies were much less likely to leave a roadside planted with native vegetation, suggesting that for some butterflies, roadside restorations could serve as protective corridors through which pollinators could move in highly modified landscapes. Roadside plantings could be corridors for breeding butterflies as well as migrating butterflies.

ROADSIDE HABITAT CREATION AND MAINTENANCE

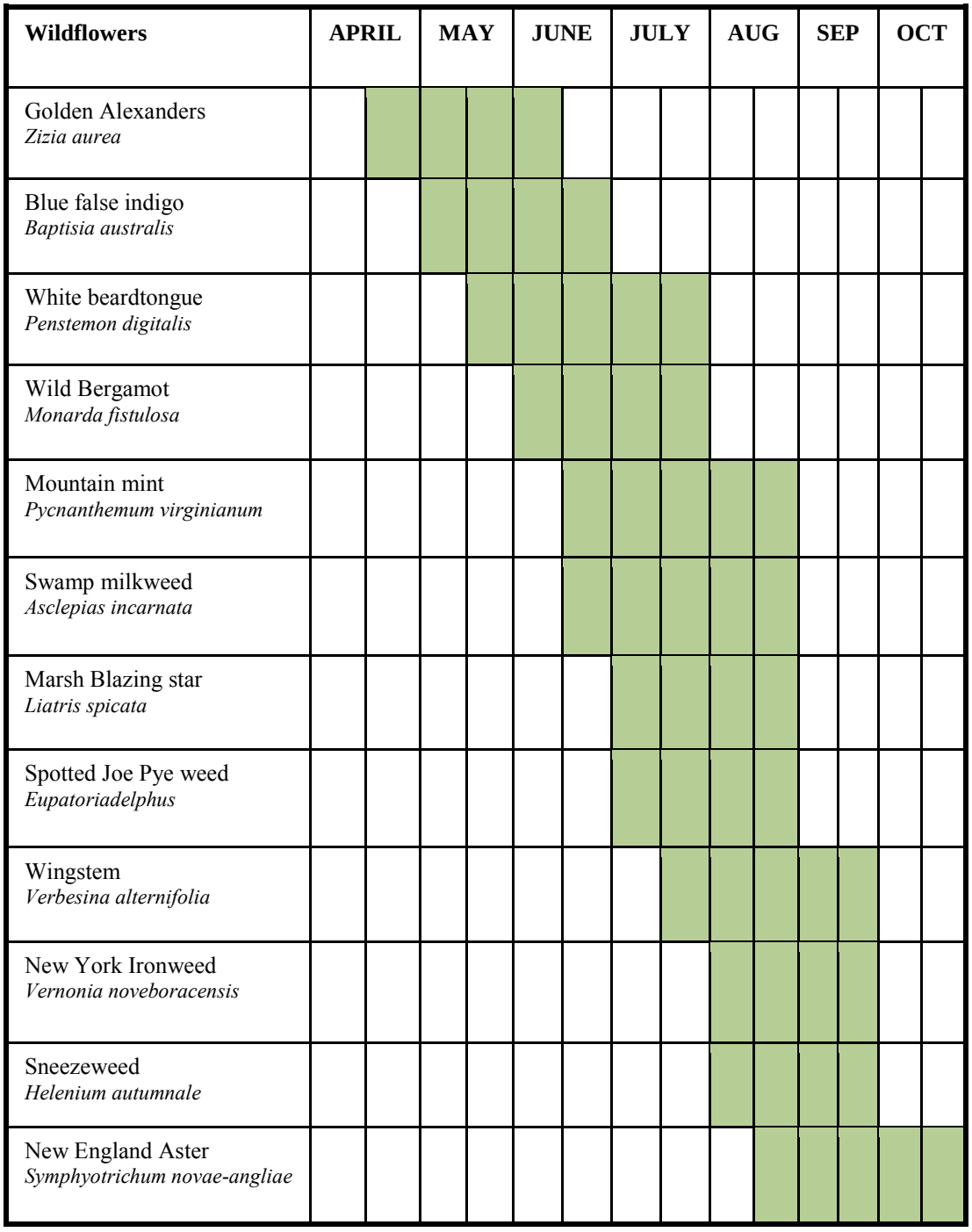
With so many acres of land in roadsides and the obvious value of these lands for wildlife due to both the quality of the habitat and the connectivity in the landscape, it is clear that roadside maintenance can be of great benefit to pollinators. The principal considerations are planting or maintaining a diversity of native plants, selecting or maintaining plants that can provide shelter for pollinators, and reducing the impact of mowing and herbicides on pollinators.

Enhancing Flower Diversity

As noted above, a diverse plant community will support a wide range of pollinator insects. When planning a new roadside project, determine the grasses and wildflowers best suited to the climate, soil type, and location of the intended habitat site. It is often tempting to have a higher ratio of grass seeds to forb seeds to keep costs of seed low, but a mix of about 50 percent forbs and 50 percent grasses will increase forb establishment (Dickson and Busby 2009). Seed mixes for roadside restorations should include flowers with differing but overlapping bloom times, to provide pollinators with continuous floral resources (Fig. 1). Plants that bloom at the same time can facilitate attraction of pollinators to nearby flowers, and those that bloom in overlapping seasons may benefit each other by supporting pollinators over time.

FIGURE 1 Example of Roadside Plants Valuable to Pollinators with Overlapping Bloom Times

Seed mixes for roadside plantings should include a number of wildflowers with overlapping bloom times. Pollinators will have a continuous source of food, and the roadside will be attractive throughout the growing season. The example below is appropriate for a mesic or moist site in the Northeast.



When maintaining an existing roadside or when designing seed mixes for new plantings, consider native plants that are valuable for conservation but that may be mistaken for noxious weeds. Native thistles are an overlooked and undervalued group of plants, in part because some introduced species are noxious weeds. Native thistles rarely cause problems for landowners adjacent to roadsides, while many species of invasive thistles can be problematic.

Native thistles are highly attractive to a wide range of pollinators (including several declining species of bumble bees) and provide food for seed-feeding birds, as well as several butterfly and moth caterpillars. Researchers at the University of Nebraska-Lincoln identified another valuable feature of native thistles. They found that the presence of a native thistle in a landscape helped to limit the abundance of a non-native thistle. The native herbivorous insects like weevils, lace bugs, and others that fed on tall thistle also attacked bull thistle, consuming more than 75% of all bull thistle seeds produced. Their study suggests that native thistles and their herbivores can help limit the spread of invasive thistles (Louda and Rand 2003).

Eradication efforts targeting non-native thistles, as well as overall loss of habitat have made thistles and the animals associated with them rare in our landscapes. It is important that roadside managers recognize the difference between noxious weeds and plants that do not cause problems, like native thistles.

Shelter for Bees and Butterflies

Host Plants for Butterflies

When selecting plants for roadside projects, the inclusion of regionally native plant species that are caterpillar host plants will support butterfly populations. If host plants are included, roadsides can provide breeding habitat for butterflies.

A loss of breeding habitat is believed to be a significant factor contributing to population declines of monarch butterflies (Brower et al. 2012; Pleasants and Oberhauser 2012; Commission for Environmental Cooperation 2008). The annual migration of monarchs in North America is a widely-known and admired phenomenon. During spring, summer, and early fall, monarchs breed throughout the United States and southern Canada, and several generations of butterflies are produced each year. Butterflies of the last generation born in late summer or early fall migrate to either central Mexico or the California coast to spend the winter congregated in forest habitats. In late winter and early spring, monarchs depart from overwintering sites in search of milkweeds on which to lay their eggs, thus starting the annual cycle again. However, the future of the monarch migration is at risk, because populations of monarchs have been declining over the past fifteen years. Milkweeds are the required host plants for monarch caterpillars. Agricultural intensification, suburban development, and the use of mowing and herbicides to control roadside vegetation have eradicated milkweeds in areas in which these activities are conducted (Commission for Environmental Cooperation 2008), reducing breeding habitat for monarchs.

Declines in milkweed habitat and monarch breeding potential illustrate the need to protect existing milkweed populations and also to increase the abundance of milkweeds through restoration activities. Including host plants such as milkweeds in roadside plantings can allow butterflies to use roadsides as breeding habitat. In addition to being larval host plants for monarch butterflies, milkweeds play an important role in supporting both native bees and honey bees. Milkweed flowers attract a tremendous variety of insects because their abundant, high quality nectar is readily accessible to flower visitors.

Table 1 Monarch Host Plants that are Commercially Available
Milkweeds (*Asclepias* spp.) occur in a diversity of plant communities across the United States. Species that are most suitable for use in large-scale habitat restoration efforts are listed below by region. All species listed are known to be used by monarchs as host plants. The commercial availability of milkweed seed is currently limited in the Southeast, Southwest, and the Great Basin, but inventory is expected to increase over the coming years. Milkweed seed is not currently available in significant quantities in the Pacific Northwest, most of the Mountain States, or the Northern Great Plains (however, there is far less monarch breeding activity in these regions as compared to the other regions listed).

Region	**Common name**	**Scientific name**
Northeast	Swamp milkweed Common milkweed Butterfly milkweed	*Asclepias incarnata* *Asclepias syriaca* *Asclepias tuberosa*
Southeast	Butterfly milkweed	*Asclepias tuberosa*
Midwest	Swamp milkweed Prairie milkweed Common milkweed Butterfly milkweed	*Asclepias incarnata* *Asclepias sullivantii* *Asclepias syriaca* *Asclepias tuberosa*
South Central	Antelope horns Green milkweed	*Asclepias asperula* ssp. *capricornu* *Asclepias viridis*
Southwest	Rush milkweed Spider milkweed Showy milkweed Broadleaf milkweed	*Asclepias subulata* *Asclepias asperula* ssp. *asperula* *Asclepias speciosa* *Asclepias latifolia*
Great Basin	Showy milkweed Narrowleaf milkweed	*Asclepias speciosa* *Asclepias fascicularis*
California	Showy milkweed Narrowleaf milkweed Indian milkweed Purple milkweed	*Asclepias speciosa* *Asclepias fascicularis* *Asclepias eriocarpa* *Asclepias cordifolia*

Despite their native status, unique beauty, and value to the monarch butterfly and a tremendous range of pollinators and other beneficial insects, milkweeds are often perceived as a problem plant and are eradicated from agricultural areas, rangelands, and roadsides.

Providing Nest Sites for Native Bees

Bees that nest in the ground often prefer to dig their nests in patches of exposed earth, and while some species prefer sunny exposed slopes, others prefer level ground (Linsley 1958). Roadsides with trenches or ditches may provide more diverse locations for ground nesters. Including native bunch grasses in seed mixes has two benefits to native bees: bumble bees may nest under the clumps, and bunch grasses stabilize ground while leaving patches of bare earth. While it may seem counterintuitive to roadside managers often faced with the task of preventing erosion, leaving small patches of exposed ground will allow bees to nest. To encourage cavity nesting bees, consider leaving native shrubs along roadside borders.

Reducing the Impact of Mowing

Mowing is widely used to maintain roadside vegetation. Although plantings of native grasses and forbs in rights-of-way should reduce the need to mow, it will still be necessary. Mowing generally has two aims: to improve driver visibility and to provide room for a vehicle to pull off the road if needed. Even if tall grasses are planted, there is no need to mow the entire roadside to achieve these objectives; it is only necessary to mow the portion of the road next to the shoulder, and the areas required for safety. However, determining appropriate times to mow may be a balancing act. Both the time of year to mow and the frequency of mowing have ecological consequences on roadside vegetation and in turn, its value to pollinators.

In general, mowing improves the diversity of the grassland habitat. Plant diversity was highest when roadsides in the Netherlands were mown twice a year, early and late in the growing season (Forman et al. 2003). A separate study from the Netherlands, found that twice yearly mowing (early summer and late autumn) was most beneficial for flower visiting insects (Noordijk et al. 2009). Collins et al. (1998) showed that in the U.S. Midwest mowing once a year in July knocked back dominant grasses and promoted wildflower growth. However, mowing at such a time will limit the growth of any fall wildflowers, such as asters and sunflowers, which are not only important forage sources for generalist insects but are also flowers which some specialist bees preferentially visit and are dependent upon. Mowing once a year in the early spring or late autumn, when pollinators are less active, or mowing every few years, may have the least impact on pollinators.

While mowing several times during the first growing season can control noxious weeds and help native plants establish, frequent mowing in subsequent years reduces native plant growth and the ability of forbs to compete with grasses. For example, excessive mowing may have led to a decrease in flowers and a subsequent decrease in bumble bees in Belgium (Rasmont et al. 2006).

Pollinators are not the only wildlife vulnerable to the effects of mowing. Some Departments of Transportation (DOTs) have found ways to accommodate wildlife while managing roadsides effectively. Some ways in which DOTs have adapted mowing are:

- Minnesota DOT requires that the first eight feet from the shoulder or road be mown on a regular basis, but the entire right-of-way may only be mown between July 31 and August 31, in order to protect nesting birds.
- The state of Wisconsin works with state and federal agencies to protect roadside habitat of the federally endangered Karner Blue butterfly. The sundial lupine is the host plant for Karner blue caterpillars, and can be common along roadsides. To prevent mowing of existing populations of these plants, Wisconsin DOT marks populations and avoids mowing them, allowing both lupine and the butterflies to persist in roadsides (Forman et al. 2003).

Highway safety and good habitat are not mutually exclusive. Ultimately, roadside managers should develop a mowing policy that addresses the safety concerns of their area and the practicality of maintenance, while also considering potential benefits to the plant and animal communities.

Reducing the Impacts of Herbicides

Herbicides can have both direct and indirect impacts on pollinators. Direct contact with herbicides can be harmful to bees or butterflies. For example, in several studies, butterflies exposed to herbicides had reduced survivorship (Russell and Schultz 2009; Stark et al. 2012). A reduction in caterpillars or pupa surviving to adults due to herbicide exposure can impact butterfly populations (Stark et al. 2012).

Herbicides can indirectly harm pollinators by removing their food supply. The sudden removal of host plants will cause caterpillars to starve, and the disappearance of plants that provide pollen and nectar will force bees and butterflies to find new habitat elsewhere.

Herbicides are important tools for managing roadside habitat. However, it is important to use herbicides with care in order to limit their impact on pollinators, particularly declining species that utilize roadsides (e.g. monarch butterfly, Karner blue butterfly). Spot treat individual invasive plants with a backpack sprayer, weed wiper, or similarly well-targeted technique. Avoid broadcast spraying or pellet dispersal so that large numbers of larval host plants or adult forage plants are not destroyed.

TRAFFIC AND WILDLIFE

For many roadside managers, the biggest concern about the presence of taller native vegetation along roads is that it will increase the number of accidents involving deer. Although there has not been a study that specifically examines the relationship between native tall grasses planted on roadsides and deer collisions, evidence from other studies indicates that the presence of tall vegetation does not increase deer-related collisions. Indiana's Department of Transportation planted shrubs along roadsides, and monitored mammal and bird mortality over a year in both planted and non-planted roadsides. They concluded that the plantings did not significantly affect the incidence of road kill (Roach

and Kirkpatrick 1985). Also, because deer often preferentially eat tender new growth of vegetation over tough older growth, allowing native plants to grow without frequent mowing may encourage fewer deer to browse in roadsides (Bonnie Harper-Lore, Federal Highway Administration, personal communication). It has also been suggested that taller grasses can provide a more secure place for deer to hide, reducing their need to bolt as well as deer accidents (Joy Williams, Iowa Department of Transportation, personal communication).

Impacts of Roads on Pollinators

Movement is fundamental to an animal's life, and roads can be barriers to animals, dividing and blocking movement between habitats. The degree to which roads are restrictive to animals appears to vary greatly between species (Bennett 1991), and although literature describing possible barrier effects of roads focuses primarily on mammals, it is likely that responses of insects to roads are also highly variable. Strong fliers are less likely to be isolated, and some insects are more vulnerable to traffic mortality than others. Butterflies appear to be one of the more common groups of insects to be killed along roads (Rao and Girish 2007). That pollinating insects do die as a result of collisions with passing vehicles is certain, but further quantifying the impacts of vehicular traffic on pollinators is challenging and studies of the impacts of roads on insects are few.

In a thorough study of butterfly diversity, mortality, and movement within roadsides, Munguira and Thomas (1992) concluded that roads could not be considered barriers to the movement of any butterflies they observed. Although between 0.6 and 7% of butterfly species were killed by vehicles, the authors considered those mortalities to be small compared to mortality due to natural factors. In a survey of butterflies in roadsides and killed on roads in Poland, Skorka et al. (2013) found that some species were more likely to be killed by vehicles than others, but on average about 8.2% of individuals for a particular species were killed on roads.

Surprisingly, a roadside inventory of dead Lepidoptera along roads in Illinois found that observed mortality was highest at an intermediate level of traffic, with lowest mortality at the highest and lowest rates of traffic (McKenna et al. 2001). The amount of traffic on nearby roads did not correlate with numbers of butterflies (Munguira and Thomas 1992) or with bee richness or abundance (Hopwood 2008) in roadside habitats.

In Iowa, research found that more butterflies were killed in predominately grassy roadsides than in roadsides planted with prairie vegetation, and only 2.8% of butterflies observed crossing the road were hit by cars (Ries et al. 2001). A landscape study of butterflies in grasslands suggested that the positive correlation between several butterflies and roads was due to the availability of host plants in roadsides, or the increased connectivity roadsides provided within the landscape (Davis et al. 2007). Skorka et al. (2013) found that the frequency of mowing was linked to the proportion of butterflies killed on roads; butterflies that had to disperse to find new habitat after roadsides were mowed may have had a greater likelihood of collisions with vehicles. The researchers

also found that roadsides with more species of plants had fewer butterflies killed by traffic (Skorka et al. 2013).

To date, research suggests that the benefit to pollinators from roadside native habitat outweighs the hazard from passing vehicles.

BALANCING THE COSTS WITH THE BENEFITS

Native grass and wildflower seed does cost more per acre than typical turfgrass seed. Seeds of certain species with a limited distribution may be particularly expensive. One way to reduce costs is to harvest seeds, with permission, from established stands of grasses or wildflowers. Modest amounts of seed can be harvested in the fall by hand, with the help of volunteers, or sometimes through the use of farming equipment. Another advantage of collecting seed locally is that local ecotypes may be particularly well adapted to the area.

Even with the higher costs of seeds and planting, managing roadsides with native vegetation may ultimately be more cost effective. Management of powerline rights-of-way through native plantings along with selective use of herbicides and manual removal of woody plants, rather than repeated mowing and blanket herbicide use, reduces maintenance costs (Russell et al. 2005). Roadsides planted with native grasses and forbs should, after establishment, have reduced erosion as well as a reduced need for mowing and spraying of herbicides, which may provide savings (Steven Holland, Iowa Department of Transportation, personal communication). In 1987, Massachusetts' Department of Public Works spent about $330 per acre to mow roadside turf six times; for every acre managed instead as wildflowers, nearly $280 could be saved by a reduction in mowing (Platt et al. 1994). Reduced storm water flow and reduced blowing snow due to native plantings are more difficult to calculate but also may likely produce savings (Steven Holland, Iowa Department of Transportation, personal communication).

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BIOGRAPHICAL SKETCH

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