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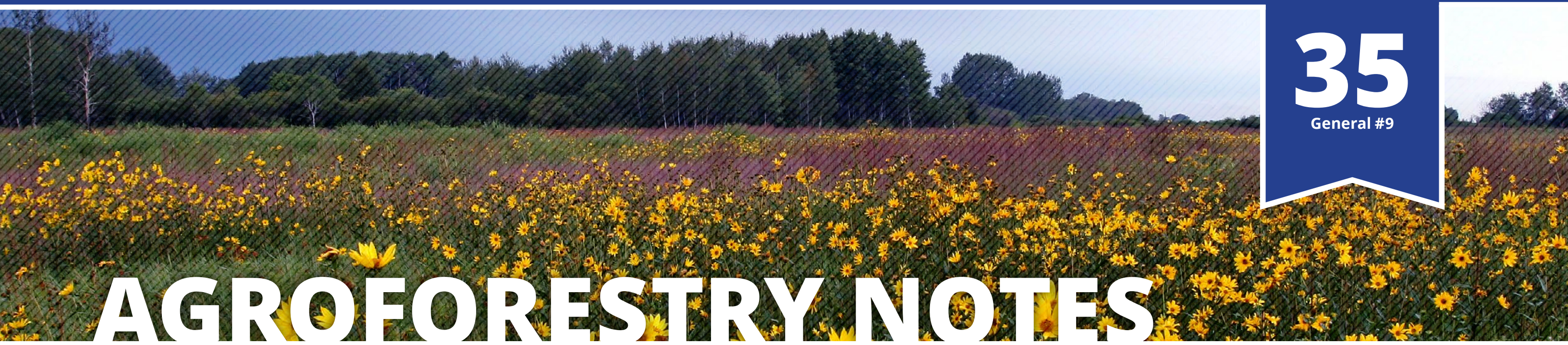

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General #9

AGROFORESTRY NOTES

Photo Credit: Gary Eslinger, U.S. Fish & Wildlife Service

Using Agroforestry Practices to Reduce Pesticide Risks to Pollinators & Other Agriculturally Beneficial Insects

Mace Vaughan / Xerces Society/NRCS West National Technology Support Center
Nancy Adamson / Xerces Society/NRCS East National Technology Support Center
Kate MacFarland / USDA National Agroforestry Center

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Introduction

Pesticides are tools commonly used to manage weeds, diseases, and crop pests. Pesticide use should be balanced against the importance of maintaining healthy populations of crop pollinators and natural enemies of crop pests that can be harmed by pesticide applications. Over 100 crops in North America depend on insect pollinators, and virtually all crop production benefits from pest control provided by predators and parasitoids. Small, diverse farms often host adequate populations of native bees and other beneficial insects in field borders and other habitat adjacent to crops or orchards. Today's larger farms, with less nearby habitat, often rely on honey bees for crop pollination and pesticides to control weeds and crop pests. Native bees, however, are important crop pollinators when habitat is available and when they are protected from pesticides, providing the majority of pollination for some crops and insurance for crops pollinated primarily by honey bees. Likewise, when allowed to thrive, natural enemies of crop pests help prevent pest outbreaks and reduce the need for pesticides.

Agroforestry practices can help reduce pesticide drift (see Diagram 1), and thus partially mitigate potential drift and negative impacts to pollinators, predators, and parasitoids in annual and perennial cropping systems. When appropriately designed, agroforestry practices also can provide refuge (from pesticides and field management/harvesting) and a safe haven for nesting and vital food resources (see Diagram 2). This Agroforestry Note focuses on pesticide risk reduction. For more on food and nesting benefits for bees from agroforestry systems, see Agroforestry Note #33 and Agroforestry Note #34.

Concerns

Insecticides

Insecticides target insects and, depending upon the timing, active ingredient, formulation and application, can pose a wide range of hazards to beneficial insects. Beneficial insects at risk include bees, butterflies, wasps, flies, beetles, lacewings, and a diversity of other predatory and parasitoid arthropods that help reduce crop pest populations. Spiders, predatory mites, and nematodes are not technically "insects," but are also beneficial as predators of crop pests. For simplicity, in this publication we use "beneficial insects" as an inclusive term to encompass these other arthropods beneficial to agriculture.

Foraging bees and other insects are poisoned by insecticides when they absorb the fast-acting toxic substances through their exoskeleton, drink nectar or water tainted by toxic substances, or gather polluted pollen or micro-encapsulated insecticides. Although direct application may kill insects, most poisonings occur from insecticide residue on plants in the hours or days after application, or from systemic insecticides that remain within plant tissues through the life of the plant. Predators and parasitoids also may be affected by toxic substances absorbed by their prey or hosts.

Diagram 1:

Potential pesticide exposure pathways encountered by pollinators in an agricultural landscape

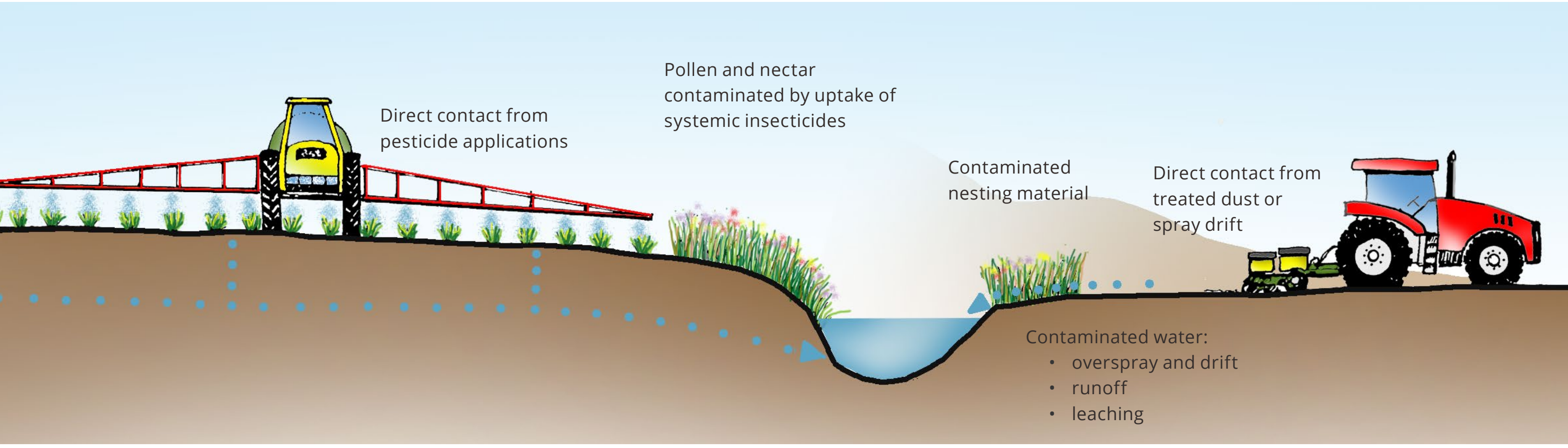


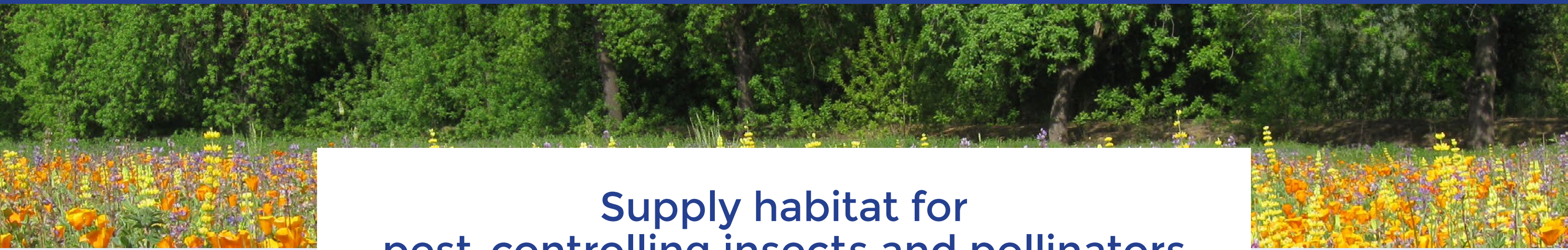
Illustration Credit: Gary Bentrup, National Agroforestry Center

Exposure risk is not restricted to contact with insecticides in the field. Toxic substances with long residual activity may be carried back to the nest and later eaten by larvae. Contaminated pollen or prey can remain toxic for a long time, killing the larvae or, in social species, the other adults in the nest. Also, nest-building materials, such as pieces of leaves, mud, plant hairs, or plant resins may contaminate nests if taken from a recently treated field or orchard, or at any time from plants treated with systemic insecticides (many of which have long residual activity).

Sub-lethal impacts of insecticides can affect development, success in mating, metamorphosis, navigation, and, for parasitoids, synchrony with host development and/or host defenses. These sub-lethal effects can reduce the number of offspring produced or lead to premature death of young and adults.

Herbicides

While herbicides do not directly target pollinators, they can destroy plants that provide nesting habitat, refuge when crops are harvested, and flowers that are vital when crops are not in bloom. They can also harm insects because the surfactants (stickers) that help ensure adherence to waxy surfaces of plant tissue also penetrate the waxy exoskeleton of insects. Spraying at night can reduce direct contact, but some male bees sleep on plants at night and other beneficial insects, particularly parasitoids, are susceptible to sprays at virtually any time.



Supply habitat for pest-controlling insects and pollinators

Multiple layers and diverse floral resources enhance the habitat value of agroforestry practices for beneficial insects, such as predators or parasitoids of pest insects, reducing the need for insecticides. They also support ground beetle populations that consume weed seeds, reducing the need for herbicides. Ideally, beneficial insects are part of an integrated pest management (IPM) program that helps to reduce overall pesticide use. There are a number of resources available on IPM approaches to support insect diversity to help reduce crop pests, improve crop pollination, and protect watershed health. See “Additional Information” for more information about these publications:

- Farming with Native Beneficial Insects
- Regional Integrated Pest Management Centers
- NRCS Agronomy Technical Note No. 9: Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices
- Effects of Agroforestry on Pest, Disease and Weed Control: A Meta-Analysis

Photo Credit: Jessa Kay Cruz, Xerces Society

Because field edges have greater plant diversity and less mechanical disturbance, they provide important refuges for beneficial insects, supporting populations that can recolonize successional crops. When vegetation is eliminated from field edges, bees must forage more widely for nectar and pollen, using more energy and increasing their exposure to threats in the landscape. As a result, they potentially produce fewer offspring.

Fungicides

Though not targeted at insects, fungicides can have both lethal and sub-lethal impacts on bees and other beneficial insects. Honey bee researchers have found that fungicides account for the majority of pesticides found in pollen and are associated with entombing behavior—bees sequestering food stores in the hive that are toxic. In addition, fungicides can amplify the toxicity of other pesticides when included in tank mixes, an increasingly common practice to reduce application costs. Honey bee researchers have also found that some fungicides can cause effects that produce symptoms similar to that of poor nutrition.

Adjacent Land Use

One of the greatest benefits of using agroforestry on farmlands includes reducing pesticide drift from and to adjacent lands. Buffers and other drift reduction strategies may be especially important if a producer has neighbors who use pesticides. Similarly, producers who use pesticides should consider the effects of those pesticides on neighboring landowners. Certified organic producers can face economic losses due to pesticide drift. While organic certification rules require buffer zones, contamination is still possible, especially if pesticides are sprayed on windy days. Communication, including with tools such as FieldWatch, can help improve coordination between neighbors. Many states have communication tools to improve communication between pesticide applicators, producers, and beekeepers.

How Agroforestry Helps

A purposefully designed agroforestry system can both reduce the impact of and need for pesticides. Agroforestry practices such as windbreaks, hedgerows, and riparian buffers can support beneficial insects by reducing risk of pesticide exposure. However, while agroforestry practices can be part of a pesticide risk reduction system, they do not entirely eliminate all risks.

Windbreaks can reduce drift by up to 80 to 90 percent when they incorporate diverse structure (mixtures of trees, shrubs, and grasses). In addition to wind speed, drift is also affected by humidity, droplet size, canopy structure, and equipment used. Even single rows of trees or shrubs have a positive impact. Properly designed agroforestry practices can greatly reduce the off-target movement of pesticides when combined with unsprayed areas of the field (i.e. setbacks).

Reduce wind

To reduce drift, most EPA pesticide labels restrict application when wind is greater than 10-15mph. However, some pesticides require lower wind speed to reduce drift. Producers should avoid application during gusty and windless conditions (due to inversion potential). Windbreaks, hedgerows, riparian buffers, and alley cropping can reduce wind speeds, helping to reduce pesticide drift onto or from a farm. A windbreak with 40-50% density will reduce wind speed by more than 50 percent, even at 10 times the height of the windbreak downwind.

Trap particulates

In addition, the leaves or needles of trees and shrubs in agroforestry plantings provide a large surface area to which droplets or particles of pesticides can adhere, similar to an air filter in your furnace or car. Evergreen species have a capture efficiency of two to four times that of broadleaf species with the additional benefit of trapping air pollutants in winter.

Deposition

Droplets of pesticides can easily adhere to dust particles. As the wind carrying particulates and droplets encounters a buffer of trees, it slows down and has less energy. Consequently, the wind can carry less material and the particulates and droplets will fall out of suspension and be deposited within and leeward of the trees. Recognize that these areas can then contain concentrations of pesticide because of the gradual accumulation of materials deposited by the wind.

Provide refuge

Windbreaks, hedgerows, and riparian buffers also can serve as safe havens for pollinators and other beneficial insects if they are well protected from pesticides. These agroforestry refugia provide supplemental forage at times when nearby crop fields or orchards are sprayed with pesticides or when annual crops are harvested, or otherwise disturbed. For example, riparian buffers with summer flowering species can also provide vital resources when drought reduces the availability of forage elsewhere. At the same time, refugia provide unpolluted nesting habitat. If herbaceous plants like milkweed and goldenrod are protected or planted in these areas, they also support monarch butterfly caterpillars or migrating adults, along with a great diversity of other wildlife. When agroforestry practices go hand in hand with best management practices including integrated pest management, the impact of pesticides on pollinators can be significantly reduced.

Diagram 2:

Using agroforestry practices to mitigate potential negativeImpacts of pesticides on pollinators

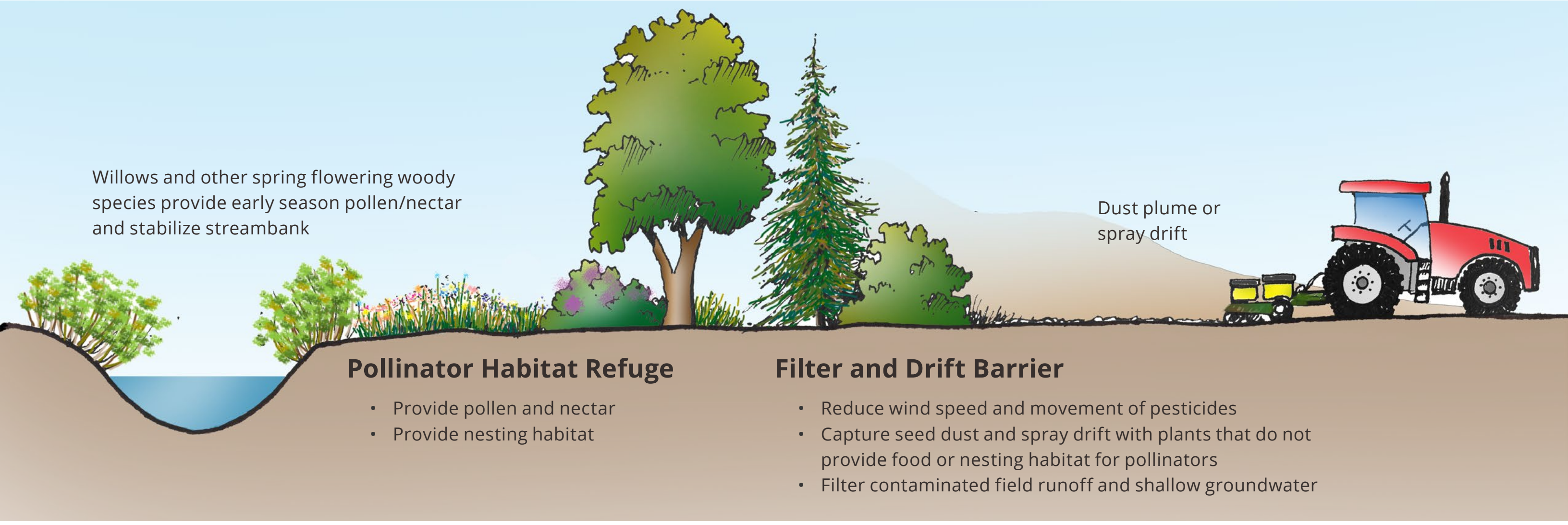


Illustration Credit: Gary Bentrup, National Agroforestry Center

Design Considerations

Effective windbreak, hedgerow, riparian or other agroforestry buffer design to reduce pesticide risks integrates farmer goals, cropping systems and their associated pesticide regimes, and the lay of the land. Location, width, and structure of buffers will depend on the crops being grown and when pesticides are likely to be used, prevailing wind patterns, whether the buffer is aimed at preventing movement of pesticide to or from the area, and other potential producer goals for the plantings (such as additional income, watershed protection, or habitat for other wildlife).

Choosing the right plants

An effective vegetative drift barrier has a 50-60 percent density consisting of several rows (see **Agroforestry Note #36** and **Inside Agroforestry Vol. 20 Issue 1** for more details). Two rows of evergreens can provide 60 percent density (40 percent porosity). Fine-leaved, dense evergreen species intercept drift due to the large surface area of their leaves or needles throughout the year. Spruce, juniper, fir, and arborvitae are recommended over pines because they have more dense foliage and pine canopies become more open with age. Shrub species are a good choice for the windward side of the windbreak because they provide surface area and moderate density close to the ground where most soil and dust particles travel. The tallest species in the planting should be one and one half times the spray release height (twice the spray height if porosity is expected to be less than 40 percent). Species on which the lower branches tend to self-prune should be avoided or supplement the planting with lower-growing species.

To protect pollinators and other insects, avoid using species that flower when pesticides are typically sprayed—this will vary with crops grown—or use a “setback” buffer planting to separate sprayed and protected areas. If drift is likely to come from only one direction, that side could be planted with species less likely to attract pollinators, such as conifers. Keep in mind that even though wind pollinated species like oaks, elms, hazelnuts, and birches don’t produce nectar, their pollen is used by bees. “Setback” buffers between 30 and 100 feet between crops and agroforestry plantings can be a mix of grasses and wildflowers that, if in flower at spray time, can be mowed prior to spray to reduce pollinator presence and potential negative impacts of pesticide drift.

Buffer width and orientation

Buffers with more rows of trees and shrubs create a denser windbreak, as well as more surface area to trap pesticide laden droplets and particulates. Generally, field windbreaks are one to three rows in width. For pesticide drift reduction, they also may need to be placed on the leeward side of crop fields to limit movement of chemicals off-site. A producer may need multiple drift barriers depending on predominant winds and the size of the fields. In temperate climates, windbreaks are commonly designed to protect against winter winds. In most of North America, winter winds come from the northwest. Spring and summer winds—when pesticides are more typically sprayed—tend to come from the south. As much as is practical, the tree rows should be planted perpendicular to the wind direction that is most common when pesticides are most likely to be applied. One tool for determining seasonal wind direction is the **wind rose**. Wind roses with monthly data for many locations around the country can be found online.

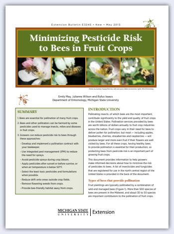
Plant spacing

Spacing between tree and shrub rows should be guided by the mature width of plants and maintenance practices (four feet wider than equipment used between rows). Where possible, in-row spacing should be on the wide side of the range for the species selected on the windward side of the windbreak and closer on the leeward side. This will allow for more

Reducing pesticide risk through proper pesticide application

Agroforestry practices more effectively reduce pesticide risk when less pesticide is applied to the landscape. Proper pesticide application is the first line of defense to prevent drifting. Formulation, timing (avoiding active times of pollinators), wind conditions, nozzle adjustments (smaller droplets travel farther and are less easily captured by vegetation), and other spray systems and techniques can reduce potential drift. More information on best management practices for insecticides, herbicides, and fungicides can be found here:

How to Reduce Bee Poisonings from Pesticides
https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw591_1.pdf



Minimizing Pesticide Risk to Bees in Fruit Crops
http://msue.anr.msu.edu/uploads/236/68700/E-3245.pdf

Pollinator Hazard Levels of Pesticide Formulations

More

- Dust
- Wettable Powder
- Flowable
- Emulsifiable Concentrate
- Soluble Powder
- Solution
- Granular, soil incorporated

Less

Granular formulations incorporated into soil and solutions are considered less toxic because they are less likely to be consumed or carried back to nests. However, they do negatively impact groundnesting insects such as bees and beetles, as well as the microflora that helps maintain plant health.

of the wind and drifting pesticide to penetrate the windbreak and be trapped or deposited. Designs with fewer rows can be planted a little more densely.

Landscape Considerations

Pesticide drift is most often associated with wind. However, pesticides can also move unintentionally off site under calm conditions when temperature inversions occur. Under these conditions pesticides can move downhill like a slow moving stream. If a field is a part of a narrow valley or drainage way leading to a river, it can be susceptible to pesticide drift. These air drainages can be interrupted by tree plantings that cut across the drainage.

Pesticides may be carried in water over land, through the soil matrix, or in streams. Adding riparian forest buffers to the landscape may reduce the transport of pesticides from a field through a watershed. Ensuring adequate buffers around streams is vital for protecting aquatic life and overall watershed health, especially when systemic pesticides with long residual activity are used.

Conclusion

Windbreaks, hedgerows, riparian buffers, and other agroforestry plantings offer a strong line of defense against drifting pesticide sprays. Depending on land use practices, these areas also provide resources and refuge for other beneficial insects. When agroforestry practices go hand in hand with best management practices, including integrated pest management, the impact of pesticides on pollinators can be significantly reduced.

Additional Information

Agroforestry Note #32: Agroforestry: Sustaining Native Bee Habitat for Crop Pollination: https://nac.unl.edu/documents/agroforestrynotes/an32g06.pdf

Agroforestry Note #33: Improving Forage for Native Bee Crop Pollinators: https://nac.unl.edu/documents/agroforestrynotes/an33g07.pdf

Agroforestry Note #34: Enhancing Nest Sites for Native Bee Crop Pollinators: https://nac.unl.edu/documents/agroforestrynotes/an34g08.pdf

Agroforestry Note #36: Windbreak Density: Rules Of Thumb for Design: https://nac.unl.edu/documents/agroforestrynotes/an36w03.pdf

Bee aware: Protecting pollinators from pesticides: http://nebraskapf.com/wp-content/uploads/2013/03/Protecting-pollinators-from-pesticides.pdf

Conservation buffers: design guidelines for buffers, corridors, and greenways: https://nac.unl.edu/buffers/index.html

How to Reduce Bee Poisonings from Pesticides: https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/pnw591_1.pdf

Minimizing pesticide risk to bees in fruit crops. Extension Bulletin: http://msue.anr.msu.edu/uploads/236/68700/E-3245.pdf

NRCS Agronomy Technical Note No. 9: Preventing or Mitigating Potential Negative Impacts of Pesticides on Pollinators Using Integrated Pest Management and Other Conservation Practices: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=34828.wba

Regional Integrated Pest Management Centers: http://www.ipmcenters.org/

Windbreaks designed with pollinators in mind. Inside Agroforestry, 20(1):8-10: http://nac.unl.edu/documents/insideagroforestry/vol20issue1.pdf#page=8

Wind Rose Resources https://www.wcc.nrcs.usda.gov/climate/windrose.html

Xerces Society Pollinator and Conservation Biocontrol Resources, http://www.xerces.org/pollinator-resource-center/ and http://www.xerces.org/conservationbiocontrol/

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Contact: USDA National Agroforestry Center, 402.437.5178 ext. 4011, 1945 N. 38th St., Lincoln, Nebraska 68583-0822. https://nac.unl.edu

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