MAKING MORE ROOM

A Companion to *Making Room for Native Pollinators*: Oregon's Butterflies, Local Plants, and Extra Resources

Matthew Shepherd, Mace Vaughan, and Scott Hoffman Black

The Xerces Society for Invertebrate Conservation, Portland, OR

THE XERCES SOCIETY
FOR INVERTEBRATE CONSERVATION

The Xerces Society for Invertebrate Conservation is an international, nonprofit, member–supported organization dedicated to preserving wildlife and its habitat through the conservation of invertebrates. The Society promotes protection of invertebrates and their habitat through science–based advocacy, conservation, and education projects. Its work focuses on three principal areas—endangered species, watershed health, and pollinator conservation. For more information about the Society or on becoming a member, please visit our website (www.xerces.org) or call us at (503) 232-6639.

Through its pollinator conservation program, the Society offers practical advice and technical support on habitat management for native pollinator insects. If you would like advice about pollinator conservation projects or want more information on pollinators, please contact Matthew Shepherd at (503) 232-6639, or by email at mdshepherd@xerces.org.

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CHAPTER 1

INTRODUCTION

In an increasingly urbanized nation—it has been calculated that more than two million acres of land in the United States are swallowed up by urban development each year—golf courses give a welcome break from the hard surfaces of towns and cities. Golf courses and other greenspaces are of growing importance in many communities, offering not just recreational opportunities but also helping to maintain a clean environment.

At the core of a healthy environment are pollinators—animals that move pollen among flowers, thus ensuring that the plants can form seeds and fruits. The work of pollinators touches our lives every day through the food we eat, and even in how we mark the seasons: think of the bloom of springtime meadows, berry picking in summer, and pumpkins in the fall.

On golf courses, these beautiful animals will not only keep your plants healthy—which in turn provides homes and food for other wildlife—but sustainable pollinator populations will also benefit nearby natural areas and neighboring gardens or farms.

Native bees and butterflies—along with flies and beetles—are among the more important wild pollinators in Oregon and Washington. Unfortunately, pollinators, like all wildlife, are suffering as landscapes change and habitats are broken up or lost. Pollinator conservation aims to support populations of pollinators.

Why Pollinators on Golf Courses?

Pollinator conservation is perfectly suited for golf courses. The basic habitat needs for pollinator insects are simple to provide and can be integrated into the current maintenance of any course, from expansive rural courses to compact urban sites.

The National Academy of Sciences report, *Status of Pollinators in North America* (NRC 2006), identified habitat loss and degradation as two causes of pollinator decline, and specifically mentioned golf courses as

Pollinator conservation is an issue of growing national urgency. Golf courses can provide extensive areas of suitable habitat in out-of-play areas. (Photograph by Matthew Shepherd.)

Bees provide flowers with the vital service of pollination. Native bees are the most important single group of pollinators in North America. (Photograph by Edward S. Ross.)

places where pollinator-friendly practices could be adopted.

These guidelines offer easy–to–implement tips for providing habitat for native bees and butterflies. In addition to helping pollinators, these practices will benefit your course in other valuable ways:

- Patches of native flowers and the butterflies and bees supported by them add diversity and visual interest.
- Habitat patches enhance golfers' experience of nature and offer a resource for community-based environmental education programs.
- Habitat projects offer the chance for increased community involvement.
- Providing habitat for pollinators will help gardeners in the neighborhoods surrounding the parks.
- Pollinator habitat supports a wide range of other wildlife, including birds and mammals.
- Pollinator conservation may also contribute to achieving "green" certification, such as the program run by Audubon International.

Some pollinators (butterflies and hummingbirds, for example) have already caught the interest of land managers and have benefited from the creation of flower gardens and meadows. Other groups of pollinators, such as bees and flies—which are each arguably more important pollinators than butterflies and hummingbirds—have yet to reach such levels of popularity. *Making More Room* is intended as a companion to *Making Room for Native Pollinators. How to Create Habitat for Pollinator Insects on Golf Courses*, published by the U.S. Golf Association in 2002. This document expands on those guidelines by offering more details of how to find existing pollinator habitat, information about butterflies and their needs, and extensive appendices containing lists of locally native plants, hostplants for caterpillars, and a comprehensive list of relevant publications.

There is a growing ethic of environmental stewardship within the superintendent's profession—and, increasingly, club members view the superintendent as someone who does more than just grow grass. They also expect him or her to take a lead in wildlife conservation and other aspects of managing a course to provide a clean, healthy environment. Maintaining pollinator populations is one of the most valuable ways in which a course can contribute to a healthy environment.

POLLINATOR BASICS—CHAPTER 2

THE ROLE AND VALUE OF POLLINATORS

All ecosystems have "keystone" species without which the ecosystem would gradually unravel and potentially collapse. Discussions of keystone species often revolve around large, mammalian predators—bears and wolves, for example. But for many land managers, especially those working in or close to urban areas, these are rare visitors, if they occur at all. By contrast, small pollinating insects are keystone species that all managers will encounter. The service these vital animals provide is a fundamental component of a healthy environment.

Pollination is the movement of pollen grains within and between flowers. It is essential for plant reproduction and the health of our environment. Some plants use wind to move pollen, but most rely upon animals—pollinators—to move it for them. Pollination is a pivotal process essential to the health and productivity of almost all terrestrial ecosystems.

The contribution that pollinators make to our lives can be measured in monetary terms. In the Pacific Northwest, pollinator–dependent crops are a mainstay of the agricultural economy. Oregon ranks first in the U.S. for harvest of blackberries, loganberries, black raspberries, boysenberries, and youngberries. Washington ranks first in the U.S. for apples, sweet cherries, and pears. Both states also produce substantial crops of vegetable and flower seed and are major producers of alfalfa. In 2001, the combined value of these pollinator–dependent crops in Oregon and Washington was nearly $2 billion.

At a national level, U.S. farmers grow more than one hundred crop plants that need pollinators. Pollinators are directly responsible for fruits and vegetables, as well as fibers such as cotton and flax. The economic value of insect–pollinated crops in the U.S. in 2000 was estimated to be $20 billion. (A more recent study calculated the value of crops pollinated by wild-living native insects alone as more than $3 billion.) This value would be many more billions if indirect products, such as the milk and beef from cattle fed on alfalfa, were considered.

> *"These insects, so essential to our agriculture and indeed to our landscape as we know it, deserve something better from us than the senseless destruction of their habitat."*
>
> *Rachel Carson*
> Silent Spring

HOW DOES POLLINATION WORK?

In order to produce seed, plants must move pollen grains either within or between flowers. Pollen grains carry gametes, the flower's male sex cells, and must transfer from the flower's anthers, where they are formed, to the tip of a stigma. Once there, the male gametes can reach and fertilize the ovules, which then develop into seed or fruit.

Pollination is often divided into two categories based on where the pollen moves and what allows the plant to set seed. Self–pollination is the movement of pollen within a flower or between flowers on a single plant. Cross–pollination is the movement between flowers on separate plants.

A significant number of plants—including grasses, rushes, and many trees—use the wind to transport pollen. These plants release huge quantities of dry, dust–like pollen grains to ensure that an adequate number will arrive at their target. Most of this pollen, however, ends up elsewhere, such as our eyes and noses: wind–blown pollen is the cause of many seasonal allergies.

Most plants—approximately 70 percent of species—have evolved an intimate relationship with one or more animals to ensure that their pollen is reliably and accurately moved. These plants produce relatively small amounts of large, sticky pollen grains that can only be carried by pollinators. Almost all pollinators are insects.

The work of pollinators has value beyond the economic impact of commercial agriculture. Pollinators are responsible for countless harvests gathered in backyards and community gardens. They support plant communities that provide food and shelter for many other animals. Fruits and seeds derived from insect pollination are a major part of the diet of approximately 25 percent of birds, as well as for mammals, from red–backed voles to grizzly bears. In some places, pollinator–supported plant communities bind the soil, thereby preventing erosion and conserving an important agricultural resource, as well as keeping creeks clean for aquatic life.

In addition, pollinators help plants in other ways beyond pollinating flowers. The tunneling activities of ground–nesting bees, for example, improve soil texture, increase water movement around roots, and mix nutrients into the soil. The larvae of pollinating beetles that tunnel in old trees increase soil fertility by helping to break down decaying wood, thus returning the nutrients locked away in the tree back into the ecosystem. The larvae of many syrphid flies (as adults, important pollinators of many plants) reduce damage to plants by eating aphids and other soft–bodied plant pests.

Large, hairy, and usually black with yellow, orange, or white stripes, bumble bees are easy to recognize. These native bees are important pollinators, and are among the first bees to be active in late winter or early spring. (Photograph by Sarah Greenleaf.)

Pollinator Basics—Chapter 3

Who Pollinates?

North American pollinators are a diverse category of animals that includes multitudes of insects and a handful of mammals and birds. The few vertebrate pollinators include white–winged doves and long– and short–nosed bats—restricted to deserts in the Southwest—and hummingbirds. It is not known exactly how many pollinator species exist on this continent, but the total number is certainly in the thousands, given that there are four thousand species of bees alone.

Almost all pollinators are insects. The four principal pollinating insect orders with members that regularly visit flowers are bees and wasps (Hymenoptera), butterflies and moths (Lepidoptera), flies (Diptera), and beetles (Coleoptera). Others that occasionally visit flowers include stoneflies (Plecoptera), true bugs (Hemiptera), scorpion–flies (Mecoptera), and thrips (Thysanoptera).

Insects visit flowers for a variety of reasons. Some are looking for food, generally nectar or pollen. Others are in search of warmth or a mate. Whatever the reason, as they go about their daily tasks flower–visiting insects transfer grains of pollen from the anthers of one flower to the stigma of the same or another flower. This transfer is not a conscious act by the pollinator. A female bee, for example, does not set out each morning with the intention to pollinate, but instead follows her instinct to feed and to collect pollen and nectar to supply her nest—incidentally spreading the pollen.

The effectiveness of insects as pollinators, however, is no accident. Over the past 150 million years, flowers and their pollinators have evolved in parallel. Insects have adapted to get the nectar and pollen (or in some cases, floral oils or other rewards) offered by the flowers, and the flowers have adapted to present pollen in a way that ensures pollination.

Pollinator–Friendly Parks focuses on native bees and butterflies. Native bees are generally considered the most important group of pollinators in temperate regions. They are (with the exception of a small group of pollen wasps) the only insects that purposefully

Native Bees: Masons, Diggers, and Carders

The diversity of bees is astonishing. About four thousand species have been identified and catalogued in North America. Only a handful of these (including the honey bee) are not native. Most native bees do not fit the stereotypical image of a bee—yellow–striped, living in a hive with thousands of others, and apt to sting—and are therefore easily overlooked.

Native bees can be dark brown, black, or metallic green and blue, with stripes of red, white, orange, yellow, or even opalescent colors. They can be as little as ⅛-inch long, or over an inch long. Most are solitary, meaning each female creates her own nest with just a few brood cells. Most are unlikely to sting. Common names reflect nest–building habits: plasterer, leafcutter, mason, carder, digger, carpenter. Other names depict traits. Cuckoo bees lay eggs in other bees' nests. Sweat bees like to drink salty perspiration. Bumble bees make a loud humming noise while flying.

Keep in mind that the yellowjackets you see eating rotting fruit and hanging around picnics are not bees, nor are they significant pollinators.

Many bees are tiny, as shown by this sweat bee dwarfed by the dandelion on which it forages. (Photograph by Scott Bauer/USDA-ARS.)

collect pollen to take back to their nests for their offspring. By contrast, other insect visitors to flowers merely brush against pollen by chance, indirectly pollinating flowers. Also, native bees make repeated trips from their nest, constantly working the same plants in a limited area, such as a park.

Winsome animals that can be used to introduce people to conservation issues, butterflies are important to consider, too. In addition to attracting the attention of park visitors, butterflies contribute to pollination. Because they may have a close association with native plants, or be found only in specific habitats, butterflies can also be indicators of overall biodiversity and measures of ecosystem health.

Another reason to focus on native bees and butterflies is that the natural history and habitat needs of these insects are better understood than those of pollinating flies or beetles. Consequently, there are well–established conservation techniques for bees and butterflies, practices that will also benefit other pollinators and species of wildlife.

Valuable pollinators include (from lower left) wasps, butterflies, and beetles. (Photograph by Jeff Adams.)

POLLINATOR BASICS—CHAPTER 4

HABITAT NEEDS OF BEES AND BUTTERFLIES

Native bees and butterflies share the same basic life cycle—egg, larva, pupa, and adult—and also the same basic habitat needs: somewhere to lay eggs, and adequate flowers on which to forage for nectar or pollen. The main difference in habitat needs is where eggs are laid. Butterflies lay their eggs on plants that are suitable for their caterpillars to eat, whereas bees create a nest in a secure location and stock it with food for their offspring.

Hostplants for butterflies

Some butterflies are very particular about which hostplants they use. Monarch caterpillars are renowned as picky eaters, that will dine only on milkweeds; thus, adult monarchs lay eggs only on these plants. Most other butterflies are less choosy about where to lay eggs, because their caterpillars will eat several plants. Caterpillars of the woodland skipper, for example, feed on many grasses, and 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 hostplant, her parental responsibility ends when she lays her eggs. Eggs and subsequently caterpillars are left to fend for themselves.

Nest sites for bees

A female bee creates a secure nest, stocks the nest with nectar and pollen for the larvae to eat, and lays eggs. The majority of bees are solitary. Approximately 70 percent nest in the ground, digging tunnels in patches of bare or sparsely vegetated soil. From this tunnel, the bee excavates a series of brood cells, into which she places a mixture of pollen and nectar and lays an egg. The remaining 30 percent of solitary bees nest, for the most part, in existing narrow holes such as old beetle tunnels in snags, or in the center of pithy twigs. Females of these wood–nesting bees create a line of brood cells, often using materials such as leaf pieces or mud as partitions between cells. The female then dies. The offspring of solitary bees typically remain in the nest for about eleven months, passing through the egg, larva, and pupa stages before emerging as an adult to renew the cycle the next year.

> *“The evidence is overwhelming that wild pollinators are declining…. Their ranks are being thinned not just by habitat reduction and other familiar agents of impoverishment, but also by the disruption of the delicate ‘biofabric’ of interactions that bind ecosystems together.”*
>
> *E. O. Wilson*
>
> *Foreword,* The Forgotten Pollinators

SOLITARY OR SOCIAL?

Asked to think of a bee nest, many people will picture the hexagonal comb and humming activity of a honey bee hive, created by the shared labor of thousands of workers, with enough stored honey to feed the colony through winter.

The nests of native bees are quite different. Almost all of the four thousand species of native bees in North America are solitary. Each female constructs and supplies her own nest, which consists of a narrow tunnel and a few brood cells stocked with nectar and pollen. She lives only a few weeks and dies after her nest is completed.

Bumble bees are social bees and live in a colony and share the labor. But, unlike honey bee nests, most bumble bee nests are a random–looking cluster of ball–shaped brood cells and waxy pots, and are occupied by fewer than a few dozen bees. Because bumble bees store only a few day’s supply of nectar, the colony does not survive beyond the fall.

Beetle–tunneled snags, like this one, and patches of bare ground are important nesting sites for solitary bees. (Photograph by Matthew Shepherd.)

As social bees that live in a colony, bumble bees need a small cavity, such as a discarded mouse nest, in which to build a cluster of waxy, pot–shaped brood cells. A queen founds a colony in spring after she emerges from hibernation. Depending on the species, the colony may be active for only a few weeks or for several months into the fall, at which time most members of the colony die. The last brood to emerge from a colony are queens and males; they mate, the males die, and the mated queens enter hibernation.

Forage needs

A butterfly forages solely for its own nutrition. Its principal food is nectar from flowers, though it will also suck fluids from other sources, such as mud, sap, fruit, and dung. In general, adult butterflies are not choosy about which flower they drink from—most species feed at dozens of different flowers—but they are limited by the length of their proboscis. Skippers and swallowtails, for example, have a long proboscis and will feed on tubular flowers such as penstemon.

Bees forage for themselves and to supply their nest. Like butterflies, solitary bees will drink nectar from any flower into which they can reach (the length of a bee's tongue varies by species). They are, by contrast, more particular about the flowers from which they gather pollen. *Generalists* gather pollen from a wide range of flower types and species. *Specialists* rely on a single plant species or on a closely related group of plants. The lifecycles of specialist bees are often closely tied to the lifecycles of their preferred host plant(s); adult bees will emerge from their brood cells right when a specific plant blooms.

Bumble bees are generalist foragers. Since the colony lives for several months, the bees must be able to collect pollen from many different flowers that bloom in succession throughout summer.

Threats to pollinator habitat

Secure, stable nesting sites and flower–rich forage areas are key components of pollinator habitat. The outright loss of this habitat is the greatest direct threat to pollinators. Sometimes the loss is dramatic—a meadow converted to a shopping mall, for example—but often it is more subtle. Sites may remain green but still lose plant diversity or nest sites; an agricultural field or an expanse of mown grass usually is of little interest to a bee or butterfly.

Flowers providing nectar and pollen are a necessary part of pollinator habitat. (Photograph by Mace Vaughan.)

The construction of new neighborhoods is one cause of habitat loss and fragmentation, and one reason why golf courses and other greenspaces are becoming increasingly important refuges for pollinators and other wildlife. (Photograph by Matthew Shepherd.)

Fragmentation of habitat is a second threat. The patches of habitat left after conversion to housing, industry, or agriculture—such as hedgerows or grassy verges—might be too small to support adequate nest sites, hostplants, or forage areas. Or, they may be too far apart. Although bees do not require large, contiguous areas of habitat, patches need to be within flying distance of each other. Most bees fly a couple of hundred yards or less between nest and forage. Butterflies can also suffer if habitat is too fragmented.

Pesticides are another significant threat. Insecticides can directly kill or injure bees and butterflies. Herbicides can reduce the availability of forage flowers. Unfortunately, both are used extensively and often without thought of pollinators. Many insecticides carry a caution notice for when they are to be used on flowering crops, intended to reduce honey bee kills. When the same pesticide is used on rangeland or for landscape maintenance, the caution notice will not apply. This is not because the toxicity changes—it does not—but because it is assumed that pollinators are not useful in these other landscapes.

The good news is that, in general, insects are able to exploit small patches and partial habitats that are suitable only for nesting or only for foraging. Wooden buildings and ornamental trees might become sites for nests; nearby urban areas might have an attractive diversity of weeds and garden plants. Small improvements to habitat may have dramatic results, at least for generalist species. Creating flower–rich field margins or hedgerows, installing bee–nesting blocks, or reducing herbicide use are ways in which you can enhance parks and greenspaces for butterflies and bees.

CONSERVATION ACTION—CHAPTER 5

STRATEGIES FOR SUCCESS

One of the encouraging aspects of pollinator conservation is the ease with which it can be adapted to different sites. Pollinators can benefit from even minimal changes, such as reducing the intensity of maintenance efforts in order to lessen the disturbance to existing habitat features. We recommend a three–step approach.

1) **Recognize the native pollinators and their habitat** that are already on your course;
2) **Adjust existing land management practices** to avoid causing undue harm to the bees already present;
3) **Enhance, restore, or create habitat** for native bees and butterflies.

A fourth strategy that should be pursued as a component of each of these steps is to **tell people what you are doing and why**. Informing golfers of how the course is changing and why can be a big step is gaining acceptance and support for the changes. Equally, getting support from managers and the relevant club committees is a vital step.

"Taking action now in response to these early alarms might allow North Americans to avert the very real and widespread declines that are now being detected among Central European bee faunas."

Jim Cane and Vince Tepedino
USDA-ARS Logan Bee Laboratory

Protecting existing native plants, such as the blanket flower shown here, or planting new patches of plants will add visual diversity to courses and enhance them for nectar-drinking insects. (Photograph by Matthew Shepherd.)

RECOGNIZE EXISTING HABITAT AND POLLINATORS

The first step in pollinator conservation is simple and requires only a small amount of money and time. You probably already regularly see butterflies and some bees. By closely observing flowers, you may start to notice more species of bees and even discover that these other species are abundant, especially if your course has or is located close to natural areas. (See Appendix C for resources on identifying native bees and butterflies.)

After discovering which native bees and butterflies are present, look for nest sites, hostplant patches, and other significant foraging patches. The next chapter, "Finding the Best Places," has details about recognizing these sites. When you find nest sites and forage areas, mark them on a map of the course. This permanent record of the significant spots for pollinators will be useful when you plan maintenance work and as you work to develop new habitat.

Sandwiched between a cart track and a pond, this unassuming slope is a good example of pollinator habitat. At least five species of bees nest in the bare ground. Identifying and protecting habitat patches such as this is a simple first step in implementing pollinator conservation. These existing patches can form a foundation on which to gradually develop additional areas of habitat. (Photograph by Matthew Shepherd.)

ADAPT CURRENT LAND MANAGEMENT

Maintenance practices can be adjusted to take into account pollinator conservation. As much as possible, leave areas that might support native bees and butterflies alone. Protect sites with potential forage plants and hostplants from mowing, herbicides, and insecticides. Reducing pesticide drift and creating buffer zones around treatment areas will go a long way toward protecting ground–nesting bees that live in or use adjacent natural areas. Leave places such as forest margins and little–used field corners unmown, reduce the frequency of mowing, and/or raise the height of the cutting blades in these areas. This will allow flowers like clover and bird's–foot trefoil to bloom, providing additional forage. Long grass can be left for bumble bees to nest in, and snags riddled with beetle tunnels should be left for mason and leafcutter bees (so long as the snags are not a hazard).

If good forage plants also happen to be weeds—an unfortunate clash of good and bad traits—rethink whether the need to remove the weeds outweighs the value to the pollinators these plants may support. It makes sense to remove the source of noxious weeds, but give a second thought to less–invasive weeds, especially if they flower in the spring and can help jumpstart populations of native bees.

ENHANCE, RESTORE, OR CREATE HABITAT

If you want to take a more active role in increasing the numbers of native pollinators, try these four steps. First, increase the available foraging habitat to include a range of plants (preferably native species) blooming at different times, in order to provide nectar and pollen throughout the season. Second, plant caterpillar hostplants appropriate for the butterfly species in your area. Third, create bee nesting sites by providing suitable ground conditions, tunnel–filled lumber, and nesting materials. Fourth, reduce the risk to pollinators from insecticides and herbicides. These substances can directly kill bees, butterflies, and other insects, as well as the plants upon which pollinators rely for forage. Instead, select less–toxic insecticides or utilize alternative strategies to manage pest insects.

TELL PEOPLE WHAT YOU ARE DOING

Education and outreach is vital to gaining the support and engagement of key people. Telling club committees, managers, and maintenance staff, as well as golfers and local community members what you are doing and why should be an integral component of your conservation efforts. Getting approval from advisory or management committees early in the process is also wise.

There are many ways to spread the word. For example, explain to maintenance staff why they will be asked to avoid mowing in some places and why these insects—often mistakenly seen as nothing more than pesky stinging bugs—are, in fact, important. Post notices on a bulletin board, have information sheets such as those produced by the Xerces Society available to read, or make pollinator conservation an agenda item at a staff meeting.

Golfers playing a round may be surprised to find grass left to grow long or patches of "weeds" appearing where they are used to seeing even–length turf. Informing them why these changes are happening may intrigue them in your new management approach—or at the very least prevent them from complaining. On–site signs (whether temporary notices or permanent interpretive panels), flyers for golfers, articles in club newsletters or on your web site, or news briefs in local media—maybe a morning spent on the course talking to golfers—all could be effective.

The following sections, combined with and *Making Room for Native Pollinators,* cover in greater detail how to enhance habitat, how to provide necessary resources, and how specific park management practices may be altered to reduce negative impacts on our native pollinators.

The wide-open spaces of many golf courses contain acres of out-of-play areas that could support abundant populations of butterflies, bees, and other pollinators. (Photograph by Matthew Shepherd.)

CONSERVATION ACTION—CHAPTER 6

FINDING THE BEST PLACES

Almost all golf course scan make a positive contribution to the abundance of pollinators. Even small, urban courses will have room for forage flowers, caterpillar hostplants, or bee nests. Because insects can utilize partial habitats—areas with nectar or pollen forage, or egg–laying sites, but not both—you can take advantage of places that are suitable for only one component of pollinator habitat. Although each single partial habitat may not provide everything bees and butterflies need, taken all together they will greatly benefit and improve your park for native pollinators.

Out-of-play areas, cart track verges, and awkward-to-mow corners behind tees are among the areas that could contain pollinator habitat. (Photograph by Matthew Shepherd.)

IDENTIFYING CURRENT HABITAT

By knowing where in your park bees and butterflies nest, lay eggs, forage, and overwinter, you will be able to protect and enhance these areas.

Spotting good foraging areas

A good foraging area contains a diversity of flower species that, ideally, offer blooms over the entire season. An area with a profusion of only a few species can also be important, especially if it is one of several patches in a landscape. You will notice many insects, mostly bees, around the best of these flowers. Look along forest margins, riparian areas, utility easements, road edges, and out-of-play areas, as well as in unused land around maintenance buildings. These sites have relatively undisturbed conditions that allow nests and bee–friendly plants to become well established. As you observe flowers, create a list of plants that are already growing in your park and that seem most attractive to native bees. This will make it easier to choose plants for future restoration projects.

Locating butterfly hostplants

To a great extent, good hostplant areas will be the same as good foraging areas. Diverse forage patches will almost certainly include a variety of hostplants. Because the caterpillars of many butterflies feed on trees, be sure to inventory your tree resources. For example, hostplants of the tiger swallowtail include willow and black cottonwood, Propertius duskywing caterpillars feed on Garry oak, and cedar hairstreak caterpillars eat western red cedar. Pay particular attention to native plants, as our local butterfly fauna is adapted to feed on these species.

Finding bee nest sites

Because the only outward signs of many bee nests are tiny holes in the ground, finding nest sites may take more effort than finding foraging areas. Also, because different species are active at different times of the day and year, search several times during the warmest months, and take into consideration the time of day. Most bees are active on warm sunny days from mid–morning through the afternoon. Some may be active primarily early in the morning. Others, such as bumble bees, will continue foraging late into the evening. In the Portland metro area, some mining bees will be visible in February, when willows flower;

some leafcutters will be active in July and August; and some sweat bees may not emerge until September. Nest sites for each of these bees will have signs of activity during these three– to six–week periods, but at other times will appear to be unoccupied.

***Ground nests*.** Species such as mining bees and sweat bees build their nests in the ground. Ground nests are often located on banks surrounding storm-water basins, ditch sides, the edges of tracks and trails, or on gently sloping hillsides with areas of sparse grass. At first, all you may see is a patch of bare ground. A closer look will reveal a scattering of small holes across the bare soil, or small mounds of soil poking up between vegetation. These mounds are sometimes mistaken for ant nests. Pause for a few minutes, and you may notice bees flying in or out of the nest entrances. Sometimes you might see low–flying males in search of a mate, punctuated by a frenzied scramble when a female appears.

***Wood nests*.** Many bees, such as leafcutters and masons, nest in beetle tunnels in snags or similar holes. Snags support other wildlife in addition to bees, so if the snags on your course do not pose a hazard, keep them. (For advice on how to retain snags and make them safe, see *Landscaping for Wildlife in the Pacific Northwest*, by Russell Link.) Wood–nesting bees will take advantage of any hole of the correct size. It is not unusual to find them nesting in the gaps between shingles or other small crevices on buildings. These bees do not harm the building; they merely utilize existing spaces.

Two types of bees can chew out their own nest tunnels. Small carpenter bees, found across the Pacific Northwest, will nest in twigs with a soft pith, such as elderberry, sumac, or blackberry; the twig might have to be broken for the bee to access the pith. Large carpenter bees, restricted in this region to the southern part of Oregon, usually make nests in the deadwood of trees such as pine, but will tunnel into the timber of buildings.

***Bumble bee nests*.** Bumble bees require a small cavity, such as an abandoned mouse nest. Most

Two examples of ground nests. On the left are the small mounds (tumuli) that surround the entrance to each nest of mining bees; there may be as many as thirty per square foot. On the right is a sweat bee nest site. These nests are marked by little more than a small hole in bare ground. When the site is active, you may also notice constant movement of low-flying males searching for a mate. (Photographs by Matthew Shepherd.)

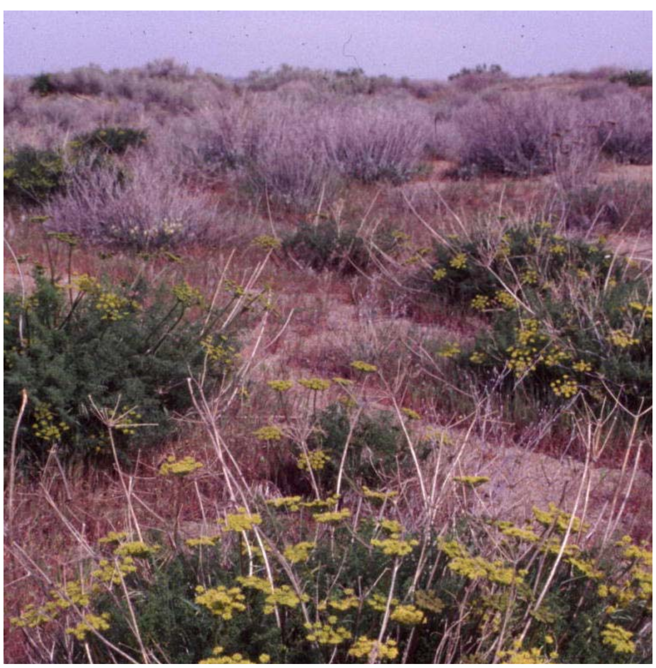
species of bumble bees prefer to nest at or below ground level. Patches of long, tussocky grass or overgrown hedge bottoms—areas preferred by mice—are typical places to find bumble bees nesting. In addition, there is at least one species (a beautiful one that is black with yellow and orange bands) that regularly nests in hollow snags or bird nesting boxes.

Course Features Friendly to Pollinators

Golf courses, even formally landscaped ones, contain many areas that could benefit pollinators.

Existing habitat

Your course may already support pollinators in areas such as forest edges, hedgerows, riparian areas, utility easements, and out-of-play areas, as well as unused land around maintenance buildings and service areas. These sites have relatively stable conditions that allow forage plants, butterfly hostplants, and bee nests to become well established. Careful management of these areas and protecting them from pesticides may create more nesting and foraging opportunities for pollinators. Existing habitat may also be enhanced with the addition of key native flowering plants and/or nesting materials.



The best foraging patches have a range of flowers that bloom through the season, providing nectar and pollen, nesting materials for bees, and caterpillar hostplants for butterflies. (Photograph by Matthew Shepherd.)

Marginal areas

Awkward-to-mow corners, fencerows, cart track and road verges, and banks of drainage ditches and ponds offer foraging and nesting habitat. If disturbance to these areas is avoided, the conditions can be relatively stable over time, which lets the soil structure and plants mature. Additionally these areas are often linear features that connect other patches of habitat, providing a corridor along which pollinators (and other beneficial insects and wildlife) can move more easily through the landscape.

Out-of-play areas

Out-of-play areas have huge potential as pollinator habitat, and are likely to be the main focus of conservation efforts on a golf course. These areas cover an extensive area of land—on many courses, their acreage is greater than the tees, fairways, roughs, and greens combined—and frequently include existing natural areas and patches of habitat. Out-of-play areas offer the possibility of interconnected habitat patches of prairie flowers, shrubs, and surrounding trees. Wildflower plantings in these areas will provide an attractive backdrop for golf as well as valuable habitat. In addition, out-of-play areas are relatively undisturbed, and thus, many of the safety issues associated with retaining snags—valuable as bee nesting sites—are minimized.

Flower gardens and formal landscaping

Although formal landscaping is not usually thought of as habitat, flower borders with pollen– and nectar–rich flowers and butterfly hostplants can be valuable for pollinators. Butterfly gardens are already being installed in many places. Small alterations to a butterfly garden, such as adding bee nesting blocks, can provide a more inclusive garden for pollinators.

Quite a few landscaping plants native to North America, but perhaps not specifically to your region, are wonderful pollinator plants and a mainstay of many gardens. Examples include Joe–pye weed, purple coneflower, and black–eye Susan. Other flower–garden plants originally from Europe and elsewhere provide abundant nectar and pollen. English lavender, fennel, and most culinary herbs are good examples. As a general rule, older varieties of perennials and herbs are the best sources of nectar or pollen. Newer flower varieties have often been bred for color, size, or

Pollinator conservation can be incorporated into any area of your course, including places traditionally not considered to be wildlife habitat. Formal landscaping, such as the rhododendron garden shown here, can offer nectar and pollen sources. (Photograph by Matthew Shepherd.)

flower structure. In the process, they may have inadvertently lost their ability to produce nectar and pollen. Modern roses, for example, may have multiple petals in the place of pollen–bearing stamens. Wooden blocks and similar bee nest sites can be a helpful, even attractive, component of these areas.

Ecolawns

Allowing low-growing flowers to bloom in turf or lawns is another way to incorporate pollinator habitat into more formal locations. Based on the traditional English lawn that provides the setting for many picture-postcard-perfect country houses, an ecolawn is a mix of grasses and low-growing perennials that will thrive and bloom beneath the cutting height of a mower. (Two inches is often the preferred cutting height.) Ecolawns require fewer inputs and less maintenance than intensively managed turf, and may be appropriate where short grass is preferred and a less manicured sward is acceptable.

SITE CHARACTERISTICS TO CONSIDER

Once you have identified potential places for improvement, decide where to start, perhaps an area in which you will have the greatest impact, one that is easier to do, or one whose improvements fit best with your overall park management plan. Here are several issues to consider when deciding among locations.

Sunshine and drainage

Topography influences drainage rates, moisture levels, sun exposure, and wind exposure, and is a significant factor on the potential value of a site for pollinators. For instance, south–facing areas are usually warmer. This tends to create better foraging and egg-laying conditions for sun–loving insects, as well as offering the drier, warmer, well–drained slopes preferred by ground–nesting bees. Plants on such sites, however, will dry out more quickly and/or need to be more drought tolerant. Therefore, establishing or protecting forage in nearby low–lying or north–facing

Native pollinators can utilize a variety of habitats. The snags in this photograph might serve as an important nesting place for wood–nesting bees. (Photograph by Matthew Shepherd.)

areas may be a critical additional step for maintaining pollinators throughout the hot summer months.

Size of habitat patch

Make habitat patches as large as is feasible within the constraints of the course. Ideally, create as many patches as possible and connect them with habitat corridors. The greater the area of habitat, the greater the likelihood that forage, hostplants, nest sites, and nesting materials will be available throughout the flight season and within the bees' flight range.

Connections between patches

In many modern landscapes, much of the natural habitat has been replaced with inhospitable land uses, resulting in significant distances between habitat patches that harbor native pollinators. Greater connectivity between fragmented patches can increase the value of the habitat to pollinators. Habitat corridors—continuous, permanent strips of vegetation that link these patches—can potentially increase the rate at which pollinators and other wildlife can colonize new areas of habitat.

For example, a few species of larger bees (such as bumble bees) can fly half a mile or more to forage, but most bees probably travel no more than a couple of hundred yards from their nests. The distance butterflies will fly similarly varies significantly by species. Some spend their whole lives in a single patch, while others have territories of a few hundred yards. Connecting habitat patches will make them more valuable.

Look beyond the boundaries of your course for connections. An adjacent power line easement, for example, could provide a corridor between habitat patches within the park.

Trees and forest

The presence of trees has several positive effects. Trees may act as a windbreak, making it easier for butterflies and bees to visit flowers and to stay warm on cooler days. (In cooler regions, bees may be less likely to build nests in areas that receive too much shade; in hot locales, shade is less likely to be a problem.) Some species of flowering trees can be excellent sources of nectar and pollen. Trees also serve as landmarks for foraging bees as they navigate to and from their nests. In addition, trees may be important hostplants for some of our most spectacular butterflies. Forest edges, with their early–successional habitat of forbs, tall grasses, and shrubs, can be valuable foraging and nesting locations for native bees. Even snags riddled with abandoned beetle tunnels might provide wood–nesting bees with nesting sites.

Maintenance access

In the long term, the effort to maintain areas of pollinator habitat should be minimal. During the establishment period, weed control and irrigation will be required. Because plants in new areas of habitat will benefit from irrigation during the first summer, keep in mind the need for access to a water supply and irrigation equipment.

CONSERVATION ACTION—CHAPTER 7

CREATING FORAGING PATCHES

Providing flowers for butterflies and native bees will make your course more attractive to pollinators, as well as be aesthetically pleasing to visitors. To be of the greatest benefit, foraging habitat should contain a range of plants that will provide a succession of flowers, and thus nectar and pollen, through as much of the growing season as possible. Carefully choose plants for a forage patch or hedgerow that will require minimal maintenance once they are established. Native plants are frequently the best choice: they are usually better adapted to grow in the climate and soils of your region, and they require little attention after they are established.

Below are tips on selecting the best plants to help bees and butterflies. See Appendix A, which has lists of native plants that are especially good for pollinators, and garden plants (native and non–native) that are excellent sources of pollen and nectar. See Appendix C for web sites and publications that focus on how to prepare a site, choose and procure seeds, sow seeds and establish plants, and maintain a site.

CHOOSING PLANTS FOR POLLINATORS

Patches of forage habitat can be created in many different places on a golf course, including out-of-play areas, hedgerows and forest edges, sides of ditches or creeks, and along cart track. Formal landscaping and flower borders beside the clubhouse and other buildings can also offer plenty of food for pollinators. When planning forage habitat, consider the following ten points.

Ensure plants flower throughout the season

In the Pacific Northwest west of the Cascades, butterflies or bees can be seen anytime between February and October, even November during a mild fall. East of the Cascades, the season is shorter, with insects emerging in March or April and pollinator insects seldom being seen after September. Most pollinators have a limited period of activity; the adults of any given species may be seen for only two to six weeks. The active adult life of many solitary–nesting bees is synchronized with the flowering period of particular plants. Bumble bees are an exception; they may be seen any time during the growing season and need food sources for a much longer period. Therefore, a sequence of plants that provide flowers through the growing season will support a wider range of pollinator species with differing flight times than will flowers that all bloom at the same time.

Ensure several plants flower at the same time

Research shows that sites with at least eight species of plants flowering simultaneously attracted a greater number and diversity of bees. This strategy will enhance your park's ability to attract and keep pollinators.

Good colors of flowers for bees are blue, purple, violet, white, and yellow (such as this tall Oregon grape). Butterflies like many of these and are also attracted by red. (Photograph by Matthew Shepherd.)

Different insects can reach nectar inside different shapes of flowers. Planting a diversity of flowers with a range of shapes—and colors—will support a diversity of different pollinators. (Photograph by Jeff Owens/Metalmark Images.)

Choose a range of flowers with diverse colors

Plants use colored flowers to attract pollinators; consequently, flower–visiting insects have good color vision to help them identify the best food sources. Bees find it hard to separate red from green, so good flower colors for these insects are blue, purple, violet, white, and yellow. Butterflies like many of these colors and are also attracted by red—as are hummingbirds. Many flowers have ultraviolet “nectar guide” markings, which we cannot see but which are highly attractive to bees and help them locate the nectar. Some red flowers such as blanket-flower, are indeed valuable for bees because of their high UV reflectance.

Choose a range of flowers with diverse shapes

Butterflies have long tongues that can probe many different flower shapes. Bees, however, differ by species in tongue length. There is a rough correlation between the depth of the flower tube and the length of the tongue of the bees that visit them. Some very open flowers, such as aster and yarrow, have nectar and pollen that is readily accessible to insects of all sizes, including short–tongued bees such as mining (*Andrena* spp.) and polyester (*Colletes* spp.) bees, as well as many flies and beetles. Other flowers, such as lupines and penstemons, have nectar that is harder to reach and is accessible only to bees that are robust enough to push between the petals (e.g., *Anthophora* spp.) or have long tongues (e.g., some bumble bees, *Bombus* spp.). A variety of flower shapes will increase the diversity of bees and other pollinators your park can support.

Use native plants

Native plants are usually well–adapted to your growing conditions, can thrive with minimum attention—after they are established—and may compete better with weed species than can non–native plants. Many native insects may be adapted to gather pollen and nectar from native plants, which are often good sources of nectar and pollen. Horticultural varieties and hybrids, in contrast, are not necessarily suited to local conditions. Also, sometimes, breeding to improve flowers, such as producing double petals, inadvertently results in the loss of the plant’s ability to produce nectar or pollen.

Get plants from local sources

The origin of wildflower seeds or plants is important. The Native Plant Society of Oregon recommends that you select plants native to your ecoregion (Oregon is divided into ten ecoregions, such as the Willamette Valley or the Columbia Basin) and use seeds or plants that originate from as close to your site as possible. When buying native species, always ask where the seed originates.

Match plants to site conditions

Environmental conditions will influence your choice of plants. A plant community designed to suit existing conditions is simpler and less expensive to establish and maintain than changing pre–existing local conditions to suit a new plant community. Note which native plants grow wild in similar conditions near to your park; this will give you some ideas about what might flourish in your site.

Think five years ahead
Consider the use of the land immediately around the habitat and how it will be affected five or ten years down the road by the size, structure, and/or needs of the plants you choose. For example, in a hedgerow next to a road or ditch or around a service area, larger trees and shrubs may be desirable to serve both as forage for pollinators and as a screen. For habitat next to sports fields, it may be better to use plants that are shorter or have a more open structure in which home–run hits and stray balls can more easily be found. Planning ahead will allow you to take into account the suitability of the mature growth forms (e.g., trees, shrubs, forbs, grasses) for a particular site, and to consider and prepare for the maintenance needs.

Avoid invasive species
Avoid non–native plant species known to be highly competitive. These invasive species will spread quickly and dominate other species, reducing the diversity and value of the habitat and increasing maintenance demands. They may also cause problems in neighboring areas. There may be city, county, or state code restrictions on certain noxious weed species. In Oregon, invasive species that should be avoided, even though they attract bees and butterflies, include Scotch broom (*Cytisus scoparius*) and butterfly bush (*Buddleja davidii*). Both of these are on the Oregon Department of Agriculture's B–list of noxious weeds (plants that should be contained and controlled to avoid further spread).

Avoid rare species
Usually, species are rare for a reason: they may require very narrow conditions for establishment, a particular habitat, or one specific pollinator. Do consider rare plant species if you know you can provide the management input or specialist knowledge required.

NON–FLORAL NUTRITION FOR BUTTERFLIES
Although flower nectar is their primary food source, butterflies also get energy from the sugars in overripe fruit, tree sap, and aphid honeydew. Male butterflies gather essential nutrients and amino acids from non–plant sources such as muddy puddles, animal carcasses, dung, and urine. You may not want to scavenge for fresh road kill for your course (although dead animals have value in wild areas), but there are some ways to provide suitable forage that you may want to consider. Along creeks or on the edge of ponds, make sure there are some sandy or muddy places. Elsewhere, dampen a shallow depression of sand and let it dry out each day. If you have fruit-bearing trees, leave some to rot.

Although generally thought of as flower-visitors, butterflies also seek out a variety of other places to get necessary nutrition. Males of a number of butterflies, in particular swallowtails and blues (shown here), gather to sip at mud and puddles. (Photograph by Edward S. Ross.)

Conservation Action—Chapter 8

Providing Butterfly Hostplants and Overwintering Sites

Planting flowers that offer nectar during summer and providing fruit and damp ground are excellent ways to help adult butterflies. It is equally important to provide habitat for the other stages of a butterfly's life. Having appropriate plants for caterpillars to eat and offering shelter during the winter will boost butterfly numbers in your park.

Caterpillar Hostplants

Caterpillars of butterflies are often highly specialized with regards to which plants they can eat, and for good reason. During this stage of its life the butterfly grows most rapidly—a caterpillar may grow thirty–fold within two or three weeks—and it is vital that it gets the proper nutrition. The range of plants on which the females of different butterfly species will lay their eggs varies enormously. The monarch (*Danaus plexippus*), for example, has a very restricted range of larval hosts; she lays her eggs only on milkweed plants. At the other extreme, the anise swallowtail (*Papilio zelicaon*) can utilize over sixty different species in the carrot family as larval hosts.

To provide the appropriate hostplants, first identify the butterflies most likely to be found in your local area, and then match them with hostplants from the region. In the northern Willamette Valley, for example, planting milkweed is highly unlikely to draw monarchs to a park, because these butterflies are rare in this region. On the other hand, anise swallowtails are common across all of Oregon, so planting desert parsley, cowparsnip, or angelica—or fennel or dill in gardens—will attract them. Appendix B lists larval hostplants for fifty common or widespread butterflies. *Butterflies of Cascadia* by R. M. Pyle contains information on all the butterflies of Oregon and Washington and their hostplants. Other good sources of information include *Butterfly Gardening: Creating Summer Magic in Your Garden* by the Xerces Society and the Smithsonian Institution, *Butterfly Gardening: Creating a Butterfly Haven in Your Garden* by T. Emmel, and *The Guide to Butterflies of Oregon and Washington* by W. Neill.

No Hostplants, No Butterflies

Caterpillar hostplants are a vital component of butterfly habitat. It is often a lack of hostplants rather than nectar plants that limit the presence of a butterfly species.

Here are examples of hostplants and their butterflies:

- **Lupine—orange sulphur, gray hairstreak, painted lady, and various blues**
- **Penstemon—Chalcedona and Edith's checkerspots, and common buckeye**
- **Cowparsnip—anise swallowtail**
- **Thistle—painted lady and Mylitta crescent**
- **Nettle—satyr anglewing, Milbert's tortoiseshell, and red admirable**
- **Violet—various fritillaries, and Oregon silverspot**
- **Idaho fescue—western branded skipper**
- **Bunchgrass—Juba skipper and ochre ringlet**
- **Willow—western tiger swallowtail, green comma, mourning cloak, and Lorquin's admiral**
- **Oceanspray—pale tiger swallowtail, spring azure, and Lorquin's admiral**
- **Garry oak—Propertius duskywing**

The Propertius duskywing nectars on many flowers as an adult, but its caterpillars will eat only Garry oak in this region. (Photograph by John Davis/GORGEous nature.)

Hostplants on which caterpillars feed are a critical part of butterfly habitat. Silvery blue laying eggs on broadleaf lupine. (Photograph by Jeff Adams.)

OVERWINTERING SITES

Most butterflies spend their entire life in one locale, including over the colder months. Depending on the species, butterflies may survive the winter in any of the four life stages: egg, caterpillar, pupa, or adult. For those species that pass the winter as eggs or caterpillars, the best protection you can offer is to leave larval host plants undisturbed during the winter months. To help butterflies that pass the winter as pupae, leave some untidy corners and piles of debris alone. Tall grass, bushes, trees, fence posts, the outside of a house or other building, or inside a pile of leaves or sticks are all places to which caterpillars will crawl to pupate. Sometimes these sites may be many yards away from larval host plants.

Under natural conditions, butterflies that overwinter as adults are likely to take shelter in tree cavities, under logs, behind loose bark, under rocks, or within evergreen foliage. Human activities have inadvertently created other viable sites, such as stone walls, buildings, and fences. Although many backyard–bird or gardening stores sell attractive overwintering boxes for butterflies, there is no evidence that the boxes work, at least not for butterflies; spiders will move in, so the boxes do have some benefit.

Create an overwintering site for adults by building a pile of logs or rocks. Logs should be stacked criss–crossed with gaps of about 6 inches between logs. Protect the stack from rain and wind with a sheet of plastic or roofing felt. (A more extensive description of how to build an overwintering pile can be found in *Mindful of Butterflies* by Bernard Jackson and Valerie Baines.) You can disguise the pile by planting nectar and larval plants around it or a creeper over it. Construct and place rock piles to give shelter from prevailing winds and rain. You do not have to use natural rock; this can be an opportunity to dispose of chunks of unwanted concrete.

Evergreen climbers growing over walls or buildings can also provide good overwintering niches for adult butterflies, as can the dense foliage of conifer trees.

Maintain shelters—such as reattaching a covering if it blows loose, replacing rotten logs, or pruning back climbers—in the summer, so that the sites are undisturbed between late fall and early spring, when they are likely to be occupied.

MIGRATION

Several butterfly species may migrate northward in the spring and summer, covering hundreds of miles. The painted lady (*Vanessa cardui*) and orange sulphur (*Colias eurytheme*) move northward in an irruption—an outward migration from a core breeding area into new territory, triggered by high population density. This does not necessarily occur every year; 2005 was the most recent big year for painted ladies in Oregon and Washington, for example. During an irruption, the adults of the final generation of the summer do not make a southward journey. Instead, they die as winter encroaches.

In contrast, one butterfly does fly south to avoid winter. Monarch butterflies overwinter in tree groves in California and in forests in the mountains of

Michoacan, Mexico. The population's northward journey the following spring occurs over a series of generations. Along the way, adults lay eggs on plants of milkweed (*Asclepias*) and then die. Gradually, as successive generations hatch, feed on milkweed, pupate, emerge as adults, and then fly north, the monarchs spread as far as southern Canada.

Migrating butterflies require foraging and egg–laying resources in two types of sites: their summer breeding sites, and in a corridor of habitat patches along their migration routes—which are usually across landscapes altered by agriculture and urbanization. Stepping–stone habitat patches, which may be nothing more than "weeds" growing on a pond margin or on a road verge, can meet these needs. A tolerant maintenance crew that leaves these areas to grow rather than cutting or spraying them may help provide the feeding or egg–laying resources these migrating pollinators require. So too with each small area of pollinator habitat created on golf courses. Left undisturbed, a patch of forage habitat or hostplants may reward you with the sight of a newly emerged butterfly warming its wings on a cool morning.

Butterflies will overwinter as an egg, caterpillar, chrysalis, or adult, depending on species. Those that overwinter as a chrysalis, such as the anise swallowtail shown here, generally find sheltered vegetation on which to spend the winter months. (Photograph by Mace Vaughan.)

CONSERVATION ACTION—CHAPTER 9

REDUCING THE IMPACT OF PESTICIDES

Pesticides can kill bees, butterflies, and other pollinator insects. The impact of pesticides on pollinators can be lethal or nonlethal, fast–acting or delayed, limited to insects in the area sprayed or—as with bees—transferred to insects in the nest.

Foraging pollinators are poisoned by pesticides when they absorb the toxins through their integument (the outer "skin" that forms their exoskeleton), drink toxin–tainted nectar, or gather pesticide–covered pollen or micro–encapsulated pesticides. If pollinators are foraging during pesticide application, the spray or dust will cover them; this may kill significant numbers of bees in the field. Pollinators foraging in recently sprayed areas absorb toxins from the residues on flowers.

Lower doses of pesticides may not kill pollinators but can affect their behavior. Bees that are exposed while foraging may have trouble navigating their way back to the nest, or they may simply be unable to fly. Other symptoms include agitated behavior, jerky or wobbly movements, or paralysis. All of these reactions make foraging and nest building difficult and may, ultimately, kill the affected insect. Sublethal doses—such as those that result from toxins brought into a nest along with nectar and pollen—may reduce egg–laying or stall the larval growth.

REDUCING THE NEED

The first step to protect pollinators is to reduce the need for pesticides. Pests can be controlled naturally, with a little patience on the part of staff. A healthy, diverse pollinator habitat has all the elements needed to encourage other beneficial insects, such as native predators or parasites of pest insects. The use of pesticides, however, often causes long–term problems by eliminating these natural enemies and upsetting the balance in the ecosystem. Whereas pests can quickly colonize and multiply in new areas of habitat, pollinators and beneficial predators may take years to return to pre–spray levels. In the weeks after an area is treated with insecticides, the pests will return, but beneficial insects will not.

Pesticides impact pollinator insects in many ways. Reducing pesticide risk is an important step toward creating healthy habitats for pollinators. (Photograph by Chris Evans, The University of Georgia/forestryimages.com.)

BUTTERFLIES AND BTK

Many different pesticides impact butterflies. One in particular causes significant risk, in part because it is considered environmentally friendly and thus its use is growing. *Bacillus thuringiensis* var. *kurstaki* (Btk) is a naturally occurring bacteria found in soils. Its use is allowed under organic growing standards, and it is also considered safe for humans and other mammals. Although it has fewer nontarget impacts than broad–spectrum pesticides such as malathion or carbaryl, Btk is not harmless to nontarget insects.

Btk may kill caterpillars of all butterfly and moth species. Lepidoptera (the butterflies and moths) is one of the most diverse insect orders, with approximately fourteen thousand species in North America. An application of Btk can kill at least two-thirds of the Lepidoptera species in the treatment area—a significant side effect, especially considering that, in addition to the adults being pollinators, caterpillars and adult Lepidoptera are a major food source for many animals such as birds and bats.

Suggestions for eliminating or reducing the need for pesticides in landscape maintenance—such as organic techniques or integrated pest management (IPM)—are available from local extension offices, resource conservation districts, and other extension support. Best management practices for organic landcare have now been developed for the U.S. and Canada (see Appendix C).

Minimizing the Risk

Pesticides are labeled with guidelines for their use. While the labels often include protections for bees, these guidelines were developed to protect honey bee hives (and, sometimes, the few other bee species managed for pollination, such as mason and leafcutter bees). They often do little to protect native bees. For example, the guidelines may require that beekeepers move hives away from spray areas or shut the bees in and cover their hives during spraying operations. Obviously, these measures are not possible with wild bees. Furthermore, beekeepers who have protected their hives are told when the area is considered safe for the bees again. There is nothing to prevent native bees from foraging in the sprayed area during the entire time the area is toxic, which, depending on the product, may be an hour or last up to two weeks.

If using pesticides, take steps to minimize the damage to pollinators and other beneficial insects. For example, choose formulations that will offer the least threat to pollinators (see Table 1, opposite). When choosing a pesticide, use a liquid formulation instead of a dust. Apply in the lowest concentration possible, only for approved uses, and only by the methods listed on the label. Avoid micro–encapsulated products: bees mistake it for pollen and will collect it to take back to the nest, which can result in the destruction of the nest.

Apply pesticides only when pollinators are inactive, such as at night or during those seasons when there are no flowers. Staff (or contractors) can learn to recognize and avoid spraying bee nest sites. Pesticide applicators should choose equipment such as hand sprayers, which will minimize drift onto adjacent plants that may be in bloom—and therefore attracting bees and butterflies—even when flowers in the treatment area are not.

Bees and Pesticides

Both the toxicity of a pesticide and the length of time recently sprayed areas remain toxic vary depending on the size of the bee. A honey bee, the standard bee by which pesticides are assessed, is a large bee with a relatively small surface–area–to–volume ratio. Because native bees are generally smaller than honey bees, with a greater surface–area–to–volume ratio, they absorb a relatively higher dose of and are more sensitive to pesticides. Thus, smaller bees will be killed by lower concentrations of insecticides, and the ones that survive will be susceptible for a longer time to the residues remaining on plants.

The foraging that makes bees such important pollinators exposes them to further risk. Slow–acting toxins may be carried back to the nest and stored in the pollen and nectar eaten by the young bees. Contaminated pollen can remain toxic for as long as a year, killing the larvae or (in colonies of social bees) the other adult bees in the nest.

Solitary–nesting bees tend to be impacted more by toxins than social bees, because the egg–laying solitary female both forages and works in the nest. A social queen remains in the nest, isolated from direct contact with pesticides, and may continue laying eggs. The effects of pesticides—and how to reduce the impacts—are discussed in great detail by C. Johansen and D. Mayer in *Pollinator Protection*. There are also several web sites, listed in Appendix C, that gives details of toxicity and residue periods for commonly used pesticides.

Table 1. Relative toxicity to bees of different pesticide formulations.

Formulation	Toxicity to bees
Dust	Most toxic
Wettable powder	
Flowable	
Emulsifiable concentrate	
Soluble powder	
Solution	
Granular	Least toxic

(Adapted from Johansen and Mayer, 1990)

CHAPTER 10
CONCLUSION

An encounter on a golf course with a butterfly—a beloved symbol of beauty that is associated with a well–functioning environment—may elicit oohs and ahhs from players who pause in the middle of a game. The contributions these and other keystone pollinator insects make to our courses goes beyond golfers' aesthetic appreciation and emotional response. The services provided by butterflies and bees are critical components of the habitats in our courses, potentially having a ripple effect to neighboring gardens and farms.

Increasingly, superintendents are expected to no only provide enjoyable playing conditions but also care for the environment of out-of-play areas and adjacent land. In Oregon and Washington, individual golf clubs may care for hundreds of acres, and half or more of these lands may be natural areas. Maintaining pollinator populations is one of the most valuable ways in which courses can contribute to a healthy environment and the conservation of biodiversity.

Pollinator conservation is well–suited to courses of all sizes and types, from those set within expansive natural areas to compact courses in urban areas. By providing and managing for bee nest sites, caterpillar hostplants, and flower–rich forage patches, superintendents and their staff will make significant contributions to the populations of pollinators in and around their courses—as well as to the health of the entire community.

Now you have read this far, you likely have an idea of how you can begin to implement pollinator conservation and what might work on your course. The best approach is to be flexible. This also lets you see what is working, what's not, and allows conservation efforts to evolve as circumstances change. Even small steps matter, and many steps require little output of time or money. More major projects can be planned to happen over a period of years.

We also hope that you will share the information in these guidelines with staff and members at your club, or maybe colleagues at other golf facilities.

These guidelines are just a start. They contain an overview of pollinator natural history and guidance on ways to increase diversity of plants and nest sites. The appendices include many useful references that will increase your knowledge. In addition, the Xerces Society can provide technical advice and detailed information about designing and implementing habitat projects.

Undoubtedly, courses can play an enormous role in sustaining populations of native pollinator insects. Many people look to golf course superintendents to take leadership roles in environmental management, not surprising given that golf courses are significant landowners in their communities. We hope the suggestions in this guide will inspire you to plan and act for insect pollinators. By enriching your course for pollinators, you will be enriching your neighborhood and entire community.

Appendix A

Pollinator-Friendly Plants

This appendix includes two lists of plants that are good sources of nectar or pollen.

The first list is of plants native to Oregon that are good for habitat patches for bees and/or butterflies. The second list gives garden plants (i.e., native to other parts of North America, Europe, or elsewhere) that would be suitable for formal landscaping.

The plants are listed alphabetically by scientific name. Plant names generally follow the USDA–NRCS PLANTS database (http://plants.usda.gov/).

For each plant, there is an indication of whether:

- the plant is native to the regions west or east of the Cascades, or to both;
- it is a caterpillar hostplant;
- it is suitable for, in List 1, formal landscaping ("Garden" column), or, in List 2, ecolawns; and
- it is deer resistant.

If only a genus is given, many species would be suitable. Consult a wildflower guide or your local native plant nursery to find species for your area.

List 1: Native Plants

Plant	Region West	Region East	Host-plant	Garden	Deer resist	Bloom period
Common yarrow (*Achillea millefolium*)	x	x	x	x	x	
Nettleleaf giant hyssop (*Agastache urticifolia*)		x		x	x	
Hooker's onion (*Allium acuminitum*)	x	x		x	x	
Slim-leafed onion (*Allium amplectens*)	x			x	x	
Nodding onion (*Allium cernuum*)	x			x	x	Jul-Aug
Geyer's onion (*Allium geyeri*)		x		x	x	
Saskatoon (*Amelanchier alnifolia*)	x	x				
Pearly everlasting (*Anaphalis margaritacea*)	x	x	x	x		Jun-Jul
Western columbine (*Aquilegia formosa*)	x	x		x		
Madrone (*Arbutus menziesii*)	x		x	x		Mar-May
Deltoid balsamroot (*Balsamorhiza deltoidea*)	x					
Arrowleaf balsamroot (*Balsamorhiza sagittata*)		x				
Serrate balsomroot (*Balsamorhiza serrata*)		x				
Harvest brodiaea (*Brodiaea coronaria*)	x			x		
Giant mountain aster (*Canadanthus modestus*)		x		x	x	
Plumeless thistle (*Carduus*)	x	x	x			
Paintbrush (*Castilleja*)	x	x				May-Aug
Fireweed (*Chamerion angustifolium*)	x	x				Jun-Aug
Yellow rabbitbrush (*Chrysothamnus viscidiflorus*)		x		x		Jul-Aug
Edible thistle (*Cirsium edule*)	x		x			
Wavyleaf thistle (*Cirsium undulatum*)		x	x			
Pink fairies (*Clarkia pulchella*)	x	x		x		May-Jun
Black hawthorn (*Crataegus douglasii*)	x	x		x	x	May
Suksdorf's hawthorn (*Crataegus suksdorfii*)	x			x		
Wild carrot (*Daucus pusillus*)	x		x	x		Jun-Aug
Menzie's larkspur (*Delphinium menziesii*)	x	x		x	x	Jun-Aug

Plant	Region West	Region East	Host-plant	Garden	Deer resist	Bloom period
Nuttall's larkspur (*Delphinium nuttallii*)	x	x		x	x	Jun-Aug
Bleeding heart (*Dicentra*)	x	x	x	x	x	
Desert shootingstar (*Dodecatheon conjugans*)		x		x		
White shootingstar (*Dodecatheon dentatum*)	x			x		
Few-flowered shootingstar (*Dodecatheon pulchellum*)	x			x		
Common willow-weed (*Epilobium ciliatum*)	x	x				
Tall annual willow-herb (*Epilobium brachycarpum*)	x	x				
Rubber rabbitbrush (*Ericameria nauseoas*)	x	x		x		Jul-Aug
Annual fleabane (*Erigeron annuus*)	x			x		
Willamette daisy (*Erigeron decumbens*)	x			x		
Philadelphia fleabane (*Erigeron philadelphicus*)	x	x		x		
Snow buckwheat (*Eriogonum niveum*)		x	x	x	x	Jun-Aug
Naked buckwheat (*Eriogonum nudum*)	x	x	x	x	x	Jun-Aug
California poppy (*Eschscholzia californica*)	x			x	x	May-Jul
Cascade aster (*Eucephalus ledophyllus*)	x		x	x	x	Jun-Aug
Showy aster (*Eurybia conspicuua*)		x	x	x	x	Jun-Aug
Thickstem aster (*Eurybia integrifolia*)		x		x	x	
Blanket-flower (*Gaillardia*)		x		x	x	Jul-Aug
Salal (*Gaultheria shallon*)	x		x	x	x	Apr-Jun
Sticky geranium (*Geranium viscosissimum*)		x				May-Jun
Oregon avens (*Geum macrophyllum*)	x	x		x		
Old man's beard (*Geum triflorum*)		x		x		
Sunflower (*Helianthus*)	x	x		x		
Pacific waterleaf (*Hydrophyllum tenuipes*)	x			x		
Scarlet gillia (*Ipomopsis aggregata*)		x		x		Jun
Columbia lily (*Lilium columbianum*)	x			x		
Desertparsley, biscuitroot (*Lomatium*)	x	x	x	x		
Meadow lotus (*Lotus denticulatus*)	x					
Seaside lotus (*Lotus formosissimus*)	x					
Small-flowered deervetch (*Lotus micranthus*)	x					
American bird's-foot trefoil (*Lotus purshianus*)	x					
Lupine (*Lupinus*)	x	x	x	x	x	May-Jun
Tall Oregon grape (*Mahonia aquifolium*)	x	x	x	x	x	Apr-Jun
Creeping Oregon grape (*Mahonia repens*)	x	x	x	x	x	May-Jun
Western crabapple (*Malus fusca*)	x		x	x		
Evening-primrose (*Oenothera*)	x	x		x		
Starvation cholla (*Opuntia polycantha*)	x	x		x	x	
Penstemon (*Penstemon davidsonii*)	x	x	x	x		May-Aug
Phacelia (*Phacelia*)	x	x		x		Jun-Aug
Mock orange (*Philadelphus lewisii*)	x			x		
Pacific ninebark (*Physocarpus capitatus*)	x	x		x		May-Jul
Bitter cherry (*Prunus emarginata*)	x	x	x			
Common chokecherry (*Prunus virginiana*)	x	x	x	x	x	Apr-May
Rhododendron (*Rhododendron*)	x		x	x	x	Apr-Jun
Squaw currant (*Ribes cereum*)	x	x		x	x	May
Western black currant (*Ribes laxiflorum*)	x			x	x	May

Plant	Region West	East	Host-plant	Garden	Deer resist	Bloom period
Redflower currant (*Ribes sanguineum*)	x			x		Apr-May
Baldhip rose (*Rosa gymnocarpa*)	x	x	x	x	x	
Nootka rose (*Rosa nutkana*)	x	x	x	x	x	May-Jun
Swamp rose (*Rosa pisocarpa*)	x	x	x	x		
Woods' rose (*Rosa woodsii*)		x	x	x		
Thimbleberry (*Rubus parviflorus*)	x	x				Mar-May
Salmonberry (*Rubus spectabilis*)	x					Mar-May
Dewberry (*Rubus ursinus* var. *macropetalus*)	x	x				
Piper's willow (*Salix hookeriana*)	x		x			
Pacific willow (*Salix lucida*)	x	x	x			
Scouler willow (*Salix scouleriana*)	x	x	x			Apr
Sitka willow (*Salix sitchensis*)	x	x	x			
Blue elderberry (*Sambucus mexicana*)	x			x	x	Apr-May
Red elderberry (*Sambucus racemosa*)	x			x	x	Jun-Jul
Narrow-leaved skullcap (*Scutellaria angustifolia*)		x		x		
Oregon stonecrop (*Sedum oreganum*)	x			x		
Spatula-leaf stonecrop (*Sedum spathulifolium*)	x			x		May-Jul
Wormleaf stonecrop (*Sedum stenopetalum*)	x	x		x		
Bolander's groundsel (*Senecio bolanderi*)	x					
Western groundsel (*Senecio intergerrimus*)	x	x				
Oregon whitetop aster (*Sericocarpus oregonensis*)	x			x	x	
Canada goldenrod (*Solidago canadensis*)	x	x		x	x	Aug-Sep
Missouri goldenrod (*Solidago missouriensis*)		x		x	x	
Munro's globe-mallow (*Sphaeralcea munroana*)		x	x	x		
Common snowberry (*Symphoricarpos albus*)	x	x	x	x		
Creeping snowberry (*Symphoricarpos mollis*)	x		x	x		
Pacific aster (*Symphytotrichum chilensis*)		x		x	x	Jul-Aug
Western mountain aster (*Symphytotrichum spathulatum*)	x	x		x	x	Jul-Aug
Douglas's aster (*Symphytotrichum subspicatum*)	x			x	x	Jul-Aug
Largeflower triteleia (*Triteleia grandiflora*)	x	x		x		
Blueberry (*Vaccinium*)	x	x	x	x		Mar-Jun
Moth mullein (*Verbascum blattaria*)	x			x		

List 2: Garden Plants

Plant	Region West	East	Host-plant	Eco-lawn	Deer resist
Yarrow (*Achillea*)	x	x		x	x
Giant hyssop (*Agastache*)	x	x			x
Hollyhock (*Alcea*)	x	x	x		
Thrift (*Armeria*)	x	x			x
English daisy (*Bellis*)	x	x		x	
Borage (*Borago*)	x	x			
California lilac (*Ceanothus*)	x	x			
Daisy (*Chrysanthemum*)	x	x			x

Plant	Region West	Region East	Host-plant	Eco-lawn	Deer resist
Coreopsis (*Coreopsis*)	x	x			x
Cosmos (*Cosmos*)	x	x			x
Foxglove (*Digitalis*)	x	x			x
Purple coneflower (*Echinacea*)	x	x			x
Globe thistle (*Echinops*)	x	x			x
Sea-holly (*Eryngium*)	x	x			x
Wallflower (*Erysimum*)	x	x			x
Fennel (*Foeniculum*)	x	x	x		
Hyssop (*Hyssopus*)	x				x
Lantana (*Lantana*)	x	x			
Sweat pea (*Lathyrus*)	x	x			
English lavender (*Lavandula*)	x	x			x
Gayfeather (*Liatris*)	x	x			
Bird’s-foot trefoil (*Lotus*)	x	x		x	
Apple (*Malus*)	x	x	x		
Mallow (*Malva*)	x	x	x		
Medick (*Medicago*)	x	x		x	
Mint (*Mentha*)	x	x			x
Four o’clock (*Mirabilis*)		x			
Bee balm (*Monarda*)	x	x			
Basil (*Ocimum*)	x	x			
Marjoram, oregano (*Origanum*)		x	x		x
Poppy (*Papaver*)	x	x			x
Selfheal (*Prunella*)	x	x		x	
Pear (*Pyrus*)	x	x			
Rosemary (*Rosmarinus*)	x	x			x
Black-eyed Susan (*Rudbeckia*)	x	x			x
Sage (*Salvia*)	x	x			x
Pin cushion (*Scabiosa*)	x				x
Sedum “Autumn Joy” (*Sedum spectabile*)	x				
Lamb’s ear (*Stachys*)	x	x			
Thyme (*Thymus*)	x	x		x	x
Clover (*Trifolium*)	x	x		x	
Nasturtium (*Tropaeolum*)	x	x	x		x
Mullein (*Verbascum*)	x	x	x		
Verbena (*Verbena*)	x	x			x
Violet (*Viola*)	x	x		x	
Zinnia (*Zinnia*)	x	x			x

Appendix B

Butterflies and Their Hostplants

This appendix lists fifty species of butterflies that are common or widespread in Oregon and Washington. Your park might attract other species; this is not a comprehensive list of the butterflies that occur in the region.

- Known hostplants are listed for each butterfly.
- Hostplant lists are based on *The Butterflies of Cascadia* by Robert Michael Pyle (Seattle Audubon Society, 2002), supplemented by *The Butterflies of North America. A Natural History and Field Guide* by James A. Scott (Stanford University Press, 1986).
- All hostplants are native to Oregon or Washington unless marked.
- Butterfly names follow *The Butterflies of Cascadia*.
- Plant names follow the USDA-NRCS PLANTS database (http://plants.usda.gov/).

Skippers (Hesperiidae)

Silver-spotted skipper (*Epargyreus clarus*)	Big deervetch (*Lotus crassifolius*), wild licorice (*Glycyrrhiza lepidota*), black locust (*Robinia pseudoacacia)*
Propertius duskywing (*Erynnis propertius*)	Garry oak (*Quercus garryana*)
Persius duskywing (*Erynnis persius*)	Broadleaf lupine (*Lupinus latifolius*), silky lupine (*L. sericeus*), goldenbanner (*Thermopsis*), milkvetch (*Astragalus*), big deervetch (*Lotus crassifolius*)
Common checkered skipper (*Pyrgus communis*)	Wide variety of mallows, including cheeseweed (*Malva parvifolia*), common mallow (*M. neglecta*), alkali malllow (*Malvella leprosa*), Munro's globemallow (*Sphaeralcea munroana*)
Juba skipper (*Hesperia juba*)	Various grasses, including Kentucky bluegrass (*Poa pratensis*), brome (*Bromus*), hairgrass (*Deschampsia*) Introduced: needlegrass (*Stipa*)
Western branded skipper (*Hesperia colorado*)	Various grasses, including Idaho fescue (*Festuca idahoensis*), brome (*Bromus*) Introduced: sheep fescue (*Festuca ovina*), needlegrass (*Stipa*), ryegrass (*Lolium*)
Sachem (*Atalopedes campestris*)	Hairy crabgrass (*Digitaria sanguinalis*), red fescue (*Festuca rubra*) Introduced: goosegrass (*Eleusine indica*), Bermuda grass (*Cynodon dactylon*)
Sandhill skipper (*Polites sabuleti*)	Various grasses, including Idaho fescue (*Festuca idahoensis*), saltgrass (*Distichlis spicata*), Kentucky bluegrass (*Poa pratensis*) Introduced: Bermuda grass (*Cynodon dactylon*)
Woodland skipper (*Ochlodes sylvanoides*)	Various grasses, including bluebunch wheatgrass (*Pseudoroegneria spicata*), Siberian wildrye (*Elymus sibiricus*), giant wildrye (*E. condensatus*) Introduced: bearded wheatgrass (*Agropyron fragile*), colonial bentgrass (*Agrostis capillaris*), common wild oat (*Avena fatua*)

Dun skipper (*Euphyes vestris*)	Sedges (*Carex*)
Common roadside skipper (*Amblyscirtes vialis*)	Various grasses, including bluegrass (*Poa*), bentgrass (*Agrostis*)

SWALLOWTAILS (PAPILIONIDAE)

Clodius parnassian (*Parnassius clodius*)	Various species of bleeding heart: Pacific bleeding heart (*Dicentra formosa*) in western parts; longhorn steer's-head (*D. uniflora*), shorthorn steer's-head (*D. pauciflora*), Dutchman's breeches (*D. cucullaria*) in eastern and drier areas.
Anise swallowtail (*Papilio zelicaon*)	Huge range of umbelliferous plants, including cow parsnip (*Heracleum*), desert parsley (*Lomatium*), wild carrot (*Daucus pusillus*), angelica (*Angelica*) Introduced: Queen Anne's lace (*Daucus carota*), fennel (*Foeniculum*)
Western tiger swallowtail (*Papilio rutulus*)	Broadleaved trees, including bigleaf maple (*Acer macrophyllum*), willow (*Salix*), aspen (*Populus tremuloides*), black cottonwood (*P. balsamifera* ssp. *trichocarpa*)
Two-tailed tiger swallowtail (*Papilio multicaudatus*)	Chokeberry (*Prunus virginianus demissa*) Introduced: green ash (*Fraxinus pennsylvanica*; in urban areas)
Pale tiger swallowtail (*Papilio eurymedon*)	Red alder (*Alnus rubra*), cascara (*Rhamnus purshiana*), oceanspray (*Holodiscus discolor*), serviceberry (*Amelanchier*), bittercherry (*Prunus emarginata*), hardhack (*Spiraea douglasii*), various species of wild lilac or buckbrush (*Ceanothus*)

WHITES AND SULPHURS (PIERIDAE)

Western white (*Pontia occidentalis*)	Crucifers, including daggerpod (*Anelsonia eurycarpa*), common pepperweed (*Lepidium densiflorum*), Virginia p. (*L. virginicum*) Introduced: clasping pepperweed (*Lepidium perfoliatum*), field pepperweed (*L. campestre*)
Sara's orangetip (*Anthocharis sara*)	Rockcress (*Arabis*), bittercress (*Cardamine*)
Clouded sulphur (*Colias philodice*)	Large number of hostplants in the pea family (Fabaceae), including milkvetch (*Astragalus*), wild sweet pea (*Lathyrus*), sweet clover (*Melilotus*), vetch (*Vicia*), sweetvetch (*Hedysarum*), lupine (*Lupinus*), goldenbanner (*Thermopsis*) Introduced: alfalfa (*Medicago sativa*), white clover (*Trifolium repens*), red clover (*T. pratense)*
Orange sulphur (*Colias eurytheme*)	Large number of hostplants in the pea family (Fabaceae), including milkvetch (*Astragalus*), wild sweet pea (*Lathyrus*), sweet clover (*Melilotus*), vetch (*Vicia*), sweetvetch (*Hedysarum*), lupine (*Lupinus*), goldenbanner (*Thermopsis*) Introduced: alfalfa (*Medicago sativa*), white clover (*Trifolium repens*), red clover (*T. pratense*), bird's-foot trefoil (*Lotus corniculatus*)

GOSSAMER-WINGS (LYCAENIDAE)

Purplish copper (*Lycaena helloides*)	Dotted smartweed (*Polygonum punctatum*), Pacific silverweed (*Argentina egedii*), silverweed cinquefoil (*Potentilla anserina*) Introduced: marshpepper knotweed (*Polygonum hydropiper*), spotted ladysthumb (*P. persicara*), sheep sorrel (*Rumex acetosella*), bitter dock (*R. obtusifolius*)
Cedar hairstreak (*Mitoura grynea*)	Western red cedar (*Thuja plicata*), Alaska yellow cedar (*Chamaecyparis nootkatensis*), incense cedar (*Libocedrus decurrans*), western juniper (*Juniperus occidentalis*)
Brown elfin (*Incisalia augustinus*)	Wide range of plants, including salal (*Gaultheria shallon*), madrone (*Arbutus*), kinnikinnick (*Arctostaphylos uva-ursi*), rhododendron (*Rhododendron*), bitterbrush (*Purshia*), big-basin sagebrush (*Artemisia tridentata*), buckwheat (*Eriogonum*), buckthorn (*Rhamnus*), Oregon grape (*Mahonia*)
Gray hairstreak (*Strymon melinus*)	Common hostplants include clover (*Trifolium*), lupine (*Lupinus*), milkvetch (*Astragalus*), rose (*Rosa*), mallow (*Malva*) Introduced: clover (*Trifolium*)
Western tailed blue (*Everes amyntula*)	A range of legumes including vetches (*Vicia*), milkvetches (*Astragalus*), locoweed (*Oxytropis*), peavines (*Lathyrus*)
Spring azure (*Celastrina argiolus*)	Osier dogwood (*Cornus*), elderberry (*Sambucus*), madrone (*Arbutus*), oceanspray (*Holodiscus discolor*), huckleberry (*Vaccinium*), cherry (*Prunus*), hardhack (*Spiraea douglasii*)
Silvery blue (*Glaucopsyche lygdamus*)	Various species of lupines, including broadleaf lupine (*Lupinus latifolius*), Pacific lupine (*L. lepidus*), silky lupine (*L. sericeus*), sulphur lupine (*L. sulphureus*); vetches (*Vicia*), milkvetches (*Astragalus*), locoweeds (*Oxytropis*), peavines (*Lathyrus*)
Melissa's blue (*Lycaeides melissa*)	Many genera of legumes, including lupine (*Lupinus*), vetch (*Vicia*), milkvetch (*Astragalus*), locoweed (*Oxytropis*) Introduced: alfalfa (*Medicago sativa*)
Greenish blue (*Plebejus saepiolus*)	Various clovers, including Alsike clover (*Trifolium hybridum*), Thompson's clover (*T. thompsonii*), cow clover (*T. wormskjoldii*) Introduced: white clover (*Trifolium repens*)
Boisduval's blue (*Icaricia icarioides*)	Various lupines, including silvery lupine (*Lupinus argenteus*), broadleaf lupine (*L. latifolius*), Pacific lupine (*L. lepidus*), silky lupine (*L. sericeus*), sulphur lupine (*L. sulphureus*) Fender's blue (*I. i. fenderi*); Federally Endangered: main hostplant is Kincaid's lupine (*L. oreganus kincaidii* [syn. *L. sulphureus kincaidii*])
Acmon blue (*Icaricia acmon*)	Many species of buckwheat (*Eriogonum*), lupines (*Lupinus*) Introduced: sweet clover (*Melilotus*)

Brush foots (Nymphalidae)

Great spangled fritillary (*Speyeria cybele*)	Pioneer violet (*Viola glabella*), hookspur violet (*V. adunca*)
Zerene fritillary (*Speyeria zerene*)	Pioneer violet (*Viola glabella*), Nuttall's violet (*V. nuttallii*), hookspur violet (*V. adunca*) <u>Oregon Silverspot (*S. z. hippolyta*); Federally Threatened</u>: hookspur violet (*V. adunca*)
Hydaspe fritillary (*Speyeria hydaspe*)	Pioneer violet (*Viola glabella*), Nuttall's violet (*V. nuttallii*), evergreen violet (*V. sempervirens*), hookspur violet (*V. adunca*)
Western meadow fritillary (*Boloria epithore*)	Pioneer violet (*Viola glabella*), Nuttall's violet (*V. nuttallii*), evergreen violet (*V. sempervirens*), pinto violet (*V. ocellata*), northern bog violet (*V. nephropylla*), hookspur violet (*V. adunca*)
Field crescent (*Phyciodes pulchellus*)	Western showy aster (*Eurybia conspicua*), Cascade aster (*Eucephalus ledophyllus*)
Mylitta crescent (*Phyciodes mylitta*)	Edible thistle (*Cirsium edule*), white thistle (*C. hookerianum*), fewleaf thistle (*C. remotifolium*), wavyleaf thistle (*C. undulatum*) <u>Introduced:</u> Canada thistle (*Cirsium arvense*), bull thistle (*C. vulgare*); yellow star-thistle (*Centaurea solstitialis*), rarely, diffuse knapweed (*C. diffusa*)
Chalcedona checkerspot (*Euphydryas chalcedona*)	Common snowberry (*Symphoricarpos albus*), mountain snowberry (*S. oreophilus*), creeping snowberry (*S. mollis*), bush penstemon (*Penstemon fruticosus*), Davidson's penstemon (*P. davidsonii*), littleflower penstemon (*P. procerus*), cliff beardtongue (*P. rupicola*) <u>Introduced:</u> mullein (*Verbascum thapsus*)
Satyr anglewing (*Polygonia satyrus*)	Nettle (*Urtica dioica*), hop (*Humulus lupulus*), willow (*Salix*)
Green comma (*Polygonia faunus*)	Willow (*Salix*), birch (*Betula*), aspen (*Populus tremuloides*), alder (*Alnus*), rhododendron (*Rhododendron*)
Mourning cloak (*Nymphalis antiopa*)	A large number of trees and shrubs, including willow (*Salix*), alder (*Alnus*), birch (*Betula*), maple (*Acer*), poplar (*Populus*), netleaf hackberry (*Celtis laevigata*), rose (*Rosa*), apple (*Malus*), spirea (*Spiraea*) <u>Introduced:</u> elm (*Ulmus*)
Milbert's tortoiseshell (*Nymphalis milberti*)	Nettle (*Urtica dioica*)

West Coast lady (*Vanessa annabella*)	Mainly mallows, including streambank globemallow (*Iliamna rivularis*), cheese-weed (*Malva rotunifolia*), fanpetals (*Sida*), checkermallow (*Sidalcea*), globemallow (*Sphaeralcea*) Introduced: hollyhock (*Alcea rosea*)
Painted lady (*Vanessa cardui*)	Thistle (*Cirsium*), plumeless thistle (*Carduus*); a wide range of plants when thistles are not available, including lupine (*Lupinus*), mallow (*Malva*), globemallow (*Sphaeralcea*), yarrow (*Achillea millefolium*), pearly everlasting (*Anaphalis margaritacea*) Introduced: Canada thistle (*Cirsium arvense*), bull thistle (*C. vulgare*), hollyhock (*Alcea rosea*)
Red admirable (*Vanessa atalanta*)	Nettles (*Urtica dioica*); pellitory (*Parietaria*), hop (*Humulus lupulus*)
Common buckeye (*Junonia coenia*)	A wide range of plants, including plantain (*Plantago*), penstemon (*Penstemon*), paintbrush (*Castilleja*), speedwell (*Veronica*), monkeyflower (*Mimulus*)
Lorquin's admiral (*Limenitis lorquini*)	Peachleaf willow (*Salix amygdaloides*), narrowleaf willow (*S. exigua*), Arroyo willow (*S. lasiolepis*), Pacific willow (*S. lucida* ssp. *lasiandra*); also aspen (*Populus tremuloides*), black cottonwood (*P. balsamifera* spp. *trichocarpa*), serviceberry (*Amelanchier*), hardhack (*Spiraea douglasii*), oceanspray (*Holodiscus discolor*), apple (*Malus*), cherry (*Prunus*)
Ochre ringlet (*Coenonympha tullia*)	Kentucky bluegrass (*Poa pratensis*). Introduced: needlegrass (*Stipa*)
Common wood nymph (*Cercyonis pegala*)	No hostplant records for this region. (Elsewhere they use tridens (*Tridens*), oat (*Avena*; introduced), needlegrass (*Stipa*; introduced))
Monarch (*Danaus plexippus*)	Various milkweeds, principally showy milkweed (*Asclepias speciosa*) and narrow-leaved milkweed (*A. fascicularis*)

Appendix C

Resources: Books, Articles, and Websites

This appendix lists books, articles, and URLs of websites that might be of interest. The focus is on materials that are written for the general public (i.e., those that avoid "heavy science") or that are easily available. For example, many of the articles can be found online.

We highly recommend five books:

- *The Forgotten Pollinators* by Buchmann and Nabhan
- *The Natural History of Bumblebees* by Kearns and Thomson
- *Bees of the World* by O'Toole and Raw
- *The Natural History of Pollination* by Procter, Yeo, and Lack
- *Pollinator Conservation Handbook* by Shepherd, Buchmann, Vaughan, and Black.

Together, these books provide a comprehensive overview of the biology of bees, the conservation issues affecting them, and practical information on what can be done to help.

All the URLs listed were correct in January 2007. If the link doesn't work, try the "root" homepage or search for the item via Google or a similar search engine.

Pollinator Biology and Conservation

Websites

The Xerces Society for Invertebrate Conservation
http://www.xerces.org

Urban Bee Gardens
http://nature.berkeley.edu/urbanbeegardens

Butterflies and Moths of North America
http://www.butterfliesandmoths.org/

Publications

Buchmann, S. L., and G. P. Nabhan. 1996. *The Forgotten Pollinators*. Washington: Island Press.

Bosch, J., and W. P. Kemp. 2001. *How to Manage the Blue Orchard Bee as an Orchard Pollinator*. Sustainable Agriculture Network Handbook Series Book 5. Beltsville, MD: Sustainable Agriculture Network.

Cane, J. H., and V. J. Tepedino. 2001. Causes and extent of declines among native North American invertebrate pollinators: detection, evidence, and consequences. *Conservation Ecology* (now *Ecology and Society*) 5(1):1. [Available online at http://www.consecol.org/vol5/iss1/art1]

Dogterom, M. 2002. *Pollination with Mason Bees. A Gardener and Naturalist's Guide to Managing Mason Bees for Fruit Production*. Coquitlam, BC: Beediverse Books.

Emmel, T. C. 1997. *Butterfly Gardening. Creating a Butterfly Haven in Your Garden*. New York: Friedman.

Frankie, G. W., R. W. Thorp, M. H. Schindler, B. Ertter, and M. Przybylski. 2002. Bees in Berkeley? *Fremontia* 30(3-4):50-58. [Available online at http://cnps.org/publications/#fremontia]

Griffin, B. L. 1993. *The Orchard Mason Bee. The Life History, Biology, Propagation, and Use of a truly Benevolent and Beneficial Insect*. Bellingham, WA: Knox Cellars Publishing.

Griffin, B. L. 1997. *Humblebee Bumblebee. The Life Story of the Friendly Bumblebees and Their Use by the Backyard Gardener*. Bellingham, WA: Knox Cellars Publishing.

Jackson, B., and V. Baines. 1999. *Mindful of Butterflies*. Lewes, UK: The Book Guild.

Johansen, C., and D. Mayer. 1990. *Pollinator Protection: A Bee and Pesticide Handbook*. Cheshire, CT: Wicwas Press.

Kearns, C., and J. Thomson. 2001. *The Natural History of Bumble Bees. A Sourcebook for Investigations*. Boulder: University Press of Colorado.

Mussen, E., M. Spivak, D. Mayer, and M. Sanford (eds.). 1999. *Bee Pollinators in Your Garden*. American Association of Professional Apiculturists. Technical Bulletin No. 2.

National Research Council. 2006. *Status of Pollinators in North America*. Washington: National Academies Press. [Available online at http://www.nap.edu/catalog/11761.html]

Natural Resources Conservation Service and the Wildlife Habitat Council. 2005. *Native Pollinators. Fish and Wildlife Habitat Management Leaflet Number 34*. [Available online at http://www.whmi.nrcs.usda.gov/technical/leaflet.htm]

Neill, W. 2001. *The Guide to Butterflies of Oregon and Washington*. Englewood, CO: Westcliffe Publishers.

O'Toole, C., and A. Raw. 1999. *Bees of the World*. London: Blandford.

Procter, M., P. Yeo, and A. Lack. 1996. *The Natural History of Pollination*. Portland, OR: Timber Press.

Pyle, R. M. 2002. *The Butterflies of Cascadia. A Field Guide to All the Species of Oregon, Washington, and Surrounding Territories*. Seattle Audubon Society, Seattle, WA.

Riedl, H., E. Johansen, L. Brewer, and J. Barbour. 2006. *How to Reduce Bee Poisoning from Pesticides.* Pacific Northwest Extension Publication 591. Oregon State University, Corvallis, OR. [Available online at http://extension.oregonstate.edu/catalog/pdf/pnw/pnw591.pdf]

Russell, K. N., H. Ikerd, and S. Droege. 2005. The potential conservation value of unmowed powerline strips for native bees. *Biological Conservation* 124(1):133-148.

Shepherd, M., S. L. Buchmann, M. Vaughan, and S. H. Black. 2003. *Pollinator Conservation Handbook. A Guide to Understanding, Protecting, and Providing Habitat for Native Pollinator Insects.* Portland, OR: Xerces Society.

Thorp, R. W., P. C. Schroeder, and C. S. Ferguson. 2002. Bumble bees: boisterous pollinators of native California flowers. *Fremontia* 30(3-4):26-31. [Available online at http://www.cnps.org/publications/publications/#fremontia]

Xerces Society and Smithsonian Institution. 1998. *Butterfly Gardening. Creating Summer Magic in Your Garden*. Berkeley: Sierra Club Books.

WILDFLOWER AND PRAIRIE ESTABLISHMENT

WEB SITES

Blackburn Nursery: *Weed Control for Wildflowers*
http://www.blackburnnursery.com/tips/weed_manage_wildflower.shtml

Garden Guides: *Solarization Techniques and Wildflower Establishment*
http://www.gardenguides.com/TipsandTechniques/solarization.htm
http://www.gardenguides.com/TipsandTechniques/wildflower.htm

Georgia Cooperative Extension Service: *Wildflower Establishment & Culture: Meadows, Beauty Spots, and Roadsides*
http://www.caes.uga.edu/publications/alpha_list.html

Lady Bird Johnson Wildflower Center: Many good articles on growing native plants and habitat restoration.
http://www.wildflower.org/?nd=articles

North Carolina Cooperative Extension Service: *Weed Management for Wildflowers*
http://www.ces.ncsu.edu/depts/hort/hil/hil-645.html

Oregon State University: *Low Maintenance Turf*
http://oregonstate.edu/dept/hort/turf/Ecolawns2005revision.pdf

Oregon State University Cooperative Extension Service: *Landscaping with PNW Native Plants*
http://extension.oregonstate.edu/yamhill/pages/gardening_natives.html

Prairie Frontier: *Wildflower and Prairie Grass Establishment*
http://www.prairiefrontier.com/pages/plantipsb.html

Prairie Nursery: *Prairie Establishment Guide*
http://www.prairienursery.com/howTo/guide/prairie_estab_guide.htm

University of Florida Extension: *Establishment of Native Wildflower Plants by Seed*
http://edis.ifas.ufl.edu/EP227

PUBLICATIONS

Aldrich, J. H. 2002. Factors and benefits in the establishment of modest-sized wildflower plantings. *Native Plants Journal* 3(1):65-73, 77-86. [Available online at http://nativeplants.for.uidaho.edu/journal/published.asp]

Allison, B. 2005. Purchasing native seeds—advice from a nurseryman. *Native Plants Journal* 6(3):295-296. [Available online at http://nativeplants.for.uidaho.edu/journal/published.asp]

Alverson, E. 2005. Preserving prairies and savannas in a sea of forest. *Plant Talk* 40(April):23-27. [Available online at http://www.eugene-or.gov/portal/server.pt/gateway/PTARGS_0_2_169666_0_0_18/Alverson-Plant-Talk-article.pdf]

Brown, R. W., and M. C. Amacher. 1999. Selecting plant species for ecological restoration: A perspective for land managers. Pages 1-16 in Holzworth, L. K., and R. W. Brown, comps. *Revegetation with Native Species: Proceedings, 1997, Society for Ecological Restoration Annual Meeting*. November 12-15, 1997. Proc. RMRS-P-

8. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Buis, S. 1998. Salvaging plants for propagation and revegetation. Pages 75-79 in R. Rose and D. L. Haase. *Symposium Proceedings: Native Plants. Propagating and Planting*. December 9-10, 1998. Oregon State University College of Forestry-Nursery Technology Cooperative.

Cambell, B. H. 2004. *Restoring Rare Native Habitats in the Willamette Valley. A Landowener's Guide for Restoring Oak Woodlands, Wetlands, Prairies, and Bottomland Hardwood and Riparian Forests*. West Linn, OR: Defenders of Wildlife. [Available online at http://www.biodiversitypartners.org/pubs/Campbell/index.shtml]

Davenport, R. 2001 Techniques used to restore Puget prairie communities and rare plant habitats. Pages 99-104 in Haase, D. L., and R. Rose. *Proceedings of the Conference: Native Plant Propagation and Restoration Strategies.* December 12-13, 2001. Oregon State University College of Forestry-Nursery Technology Cooperative and the Western Forestry and Conservation Association.

Dunne, R. A. 2002. Practicing safe seed. *Native Plants Journal* 3(1):74-76. [Available online at http://nativeplants.for.uidaho.edu/journal/published.asp]

Gustafson, D. J., D. J. Gibson, and D. L. Nickrent. 2005. Using local seeds in prairie restoration—data support the paradigm. *Native Plants Journal* 6(1):25-28. [Available online at http://nativeplants.for.uidaho.edu/journal/published.asp]

Jones, T. A. 2005. Genetic principles and the use of native seeds—just the FAQs, please, just the FAQs. *Native Plants Journal* 6(1):14-24. [Available online at http://nativeplants.for.uidaho.edu/journal/published.asp]

Jones, T. A., and S. A. Young. 2005. Native seed commerce: more frequently asked questions. *Native Plants Journal* 6(3):286-293. [Available online at http://nativeplants.for.uidaho.edu/journal/published.asp]

Link, R. 1999. *Landscaping for Wildlife in the Pacific Northwest*. Seattle: University of Washington Press.

McMahan, L. R. 2001. Native plant gardens: Practices and recommendations. Pages 35-40 in Haase, D. L., and R. Rose. *Proceedings of the Conference: Native Plant Propagation and Restoration Strategies.* December 12-13, 2001. Oregon State University College of Forestry-Nursery Technology Cooperative and the Western Forestry and Conservation Association.

Native Plant Society of Oregon. 2001. Guidelines on use of native plants for gardening. *Bulletin of the Native Plant Society of Oregon* 34(March):33-35. [Available online at http://www.npsoregon.org]

Wiesner, L. E. 1999. Important biological factors for utilizing native plant species. Pages 39-43 in Holzworth, L. K., and R. W. Brown, comps. *Revegetation with Native Species: Proceedings, 1997, Society for Ecological Restoration Annual Meeting*. November 12-15, 1997. Proc. RMRS-P-8. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Windhager, S. 2000. Restoration. The basics on how to repair your land. *Native Plants* 17(3-4):10-15. [Available online at http://www.wildflower.org/?nd=articles_res]

WILDLIFE ON GOLF COURSES

PUBLICATIONS

Bevard, D. S. 2004. Unnatural expectations. Proper establishment and maintenance of naturalized areas can increase acceptance by golfers. *Green Section Record* Jan-Feb 2004:16-18. [Available online at http://turf.lib.msu.edu/gsr/]

Dodson, R., G. 2000. *Managing Wildlife on Golf Courses*. New York: John Wiley & Sons, Inc.

Gange, A. C., D. E. Lindsay, and J. M. Schofield. 2003. The ecology of golf courses. *Biologist* 50(2):63-68. [Available online at http://www.randa.org/pdfs/the ecology of golf courses.pdf]

Gross, P. J. 2002. A sign that golf is good for the environment. Using interpretive signs on the golf course. *Green Section Record* May-Jun 2002:20. [Available online at http://turf.lib.msu.edu/gsr/]

Harker, D., G. Libby, K. Harker, S. Evans, and M. Evans. 1999. *Landscape Restoration Handbook*. 2nd Edition. Boca Raton: Lewis Publishers.

Jennings, J. 2004. Prairie fire! Using fire to improve the health and condition of unmown rough areas. *Green Section Record* Jan-Feb 2004:8-10. [Available online at http://turf.lib.msu.edu/gsr/]

Mackay, J., and P. Dotti. 2001. Edging away from manicured perfection. *Green Section Record* Mar-Apr 2001:19. [Available online at http://turf.lib.msu.edu/gsr/]

Nelson, M. 1997. Natural areas. Establishing natural areas on the golf course. *Green Section Record* Nov-Dec 1997:7-11. [Available online at http://turf.lib.msu.edu/gsr/]

Pekarek, C. 2000. Sharing the success of good stewardship. A successful effort to create environmental education opportunities right in a school's backyard. *Green Section Record* Jan-Feb 2000:20-21. [Available online at http://turf.lib.msu.edu/gsr/]

Salinetti, P. 1997. Naturalizing: A superintendent's perspective. *Green Section Record* Nov-Dec 1997:16-17. [Available online at http://turf.lib.msu.edu/gsr/]

Shepherd, M., D. Heagerty, and B. Baker. 2001. Environmental opportunity: Pollinating bugs need homes. *Golf Course Management* February 2001:55-60. [Available online at http://www.gcsaa.org/gcm/2001/feb01/02bugs.html]

Shepherd, M. D., and V. J. Tepedino. 2000. The birdies and the bees. Native pollinators on your golf course. *Green Section Record* Jul-Aug 2000:17-21. [Available online at http://turf.lib.msu.edu/gsr/]

Terman, Max R. 2000. Ecology and golf: Saving wildlife habitats on human landscapes. *Golf Course Management* January 2000:52-54. [Available online at http://www.gcsaa.org/gcm/2000/jan00/pdfs/01habitats.pdf]

Vavrek, B. 2002. Makin' hay. The use of common farm implements to manage natural roughs. *Green Section Record* May-Jun 2002:31. [Available online at http://turf.lib.msu.edu/gsr/]

Woolbright, L. 2003. The corridor connection. *Green Section Record* May-Jun 2003:41-42. [Available online at http://turf.lib.msu.edu/gsr/]

Appendix D
The Natural History of Native Bees

Bees are considered the most important group of pollinators for a simple reason: Female bees collect nectar and pollen from flowers as food for their offspring and, in doing so, carry large quantities of pollen from flower to flower. Both male and female bees feed on nectar, but only the females gather pollen and nectar to take back to her nest. A single female bee may visit tens or even hundreds of flowers on a foraging trip, actively gathering and moving pollen. Female bees have special structures on their legs and bodies to carry pollen, but some of it brushes off when they visit other flowers. This is the fundamental service of pollination.

Life cycle of bees
Like a butterfly, a bee undergoes complete metamorphosis, passing through four stages during its lifetime: egg, larva, pupa, and adult. It is only the last of these, the adult, which we see and recognize as a bee. During the first three stages, the bee is inside the brood cell of the nest. How long each stage lasts varies greatly by species, and to a great extent is defined by whether the bee is solitary or social.

Generalist or specialist?
Bees can be divided into two loose groups according to their foraging habits. *Generalists* are bees that gather nectar and pollen from a wide range of flower types and species. The majority of bees, including the social species, are generalists. *Specialists*, on the other hand, rely on a single plant species or a closely related group of plants. The life cycle of these bee species is often closely tied to their host plant(s), and the adults will emerge from their brood cells just when the plant is flowering.

Solitary or social?
Bees can also be divided into two groups according to lifestyle: social or solitary. Contrary to the stereotypical image of a bee living with thousands of sisters in a hive, only a few species are in fact social. Social bees live as a colony in a nest and share the work of building the nest, caring for offspring, and foraging for pollen and nectar. The truly social bees in the U.S. are the non–native European honey bee (*Apis mellifera*) and the bumble bees (genus *Bombus*; about forty–five species), although about two hundred species of sweat bees exhibit some level of social behavior. Just about all of the rest of the nearly four thousand species of bees in the U.S. are solitary. Each solitary female creates and provisions a nest on her own, without cooperation from other bees. Although solitary bees often will nest together in great numbers when a good nesting area is found, these bees are only sharing a nesting site, not cooperating.

Solitary Bees
Solitary bees generally live for about a year, although we see only the active adult stage, which lasts about three or four weeks. These creatures spent the previous eleven months hidden in a nest, growing through the egg, larva, and pupa stages. After emerging from the nest, a male bee typically hangs around a nesting area or a foraging site hoping to mate with a female. The female bee will mate once and then spend her time creating and provisioning a nest in which to lay her eggs.

Female native bees have amazing engineering skills, going to extraordinary lengths to construct a secure nest. About 30 percent of solitary bee species use abandoned beetle burrows or other tunnels in snags (dead or dying standing trees) or chew out a nest within the soft central pith of stems and twigs. The other 70 percent nest in the ground, digging tunnels in bare or partially vegetated, well–drained soil.

Each bee nest usually has several separate brood cells in which the female will lay her eggs. The number of cells varies by species. While some nests may have only a single cell, most have ten or more. Female wood–nesting bees make the cells in a single line filling the tunnel. Females of ground–nesting species may dig complex, branching tunnels. To protect the developing bee, the cell may be formed or lined with waxy or cellophane–like secretions, pieces of leaf or petal, soil, or chewed–up wood.

Before she closes each cell, the bee provisions it with food for her offspring. She mixes together the nectar and pollen she collected to form a loaf of "bee bread" inside the brood cell. She then lays an egg in the cell, usually on the loaf, and seals the cell. When she has completed and sealed all the cells in her nest, the bee will cap the nest entrance and leave.

A female solitary bee may lay up to twenty or thirty eggs in her life. Each egg resembles a tiny white sausage. One to three weeks later, the egg hatches and a white, soft–bodied, grub–like larva emerges. All of the bee's growth occurs during this larval stage. Feeding on the bee bread, the larva grows rapidly for six or eight weeks before changing into a pupa. During the dormant pupal stage, which may last eight or nine months, the bee transforms within a protective cocoon into its adult form. When it emerges, the adult bee is fully grown, ready to mate and continue the cycle.

SOCIAL BEES

Most social bees live very much like solitary bees—digging and provisioning a nest in the ground before sealing it and abandoning it—except that they have a few helpers.

Bumble bees are the best known social bees native to the U.S. Like non–native honey bees, bumble bees live in colonies, share the work of foraging and nest construction, and have multiple, overlapping generations throughout the spring, summer, and fall. However, unlike honey bees, bumble bee colonies are seasonal. At the end of the summer most of the bees in the colony die, leaving only a few fertilized queens to hibernate through the winter. In the spring, each surviving queen will start a new nest, which may eventually grow to include dozens to hundreds of individuals, depending on the species. Bumble bees are often the first bees active in late winter and the last to be foraging in fall. Therefore, a wide range of plant species must be available all season long to support the colony.

Bumble bees are generalist foragers, visiting a diversity of flowers, although a few groups of flowers are especially important to them. Lupines, for example are an excellent source of nectar. Bumble bees practice "buzz pollination," in which they grab onto the anthers of certain flowers and vibrate their flight muscles—with an audible buzz—to release the pollen.

Bumble bees need a suitable cavity in which to nest. Sometimes they build nests above ground, such as in hollow trees or walls or under a tussock of grass, but mostly they nest underground. Abandoned rodent holes are common nest sites, as this space is easily warmed and already lined with fur. The queen creates the first few pot–like brood cells from wax, lays eggs, and then forages to provide them with pollen and nectar. It will take at least a month for her to raise this first brood. When they emerge, these bees become workers. They take on the task of foraging and help the queen tend the growing number of brood cells. The workers may live for a couple of months. As the queen continues to lay eggs, the colony grows steadily through the summer. At the end of summer, new queens and drones will emerge and mate. When the cooler weather of fall arrives most of the bees, including the old queen, will die, leaving only the new, mated queens to overwinter.

APPENDIX E
CLEANING WOOD NESTS

For farmers or gardeners who are raising bees to provide reliable crop pollination, nest hygiene is important, and cleaning bee nests is an annual task. On golf courses, where nests have been created mainly to support native populations, nest cleaning is less of a concern. Locations where block cleaning may be more of a priority are formal gardens or demonstration sites, if it is important that the blocks look tidy and are occupied by bees every year.

Cleaning will help reduce parasites, fungi, and diseases that might affect the developing bees in their brood cells (after three or four years, the nest might produce more parasites than bees). These are threats that bees naturally face and are unlikely to be a significant maintenance concern.

The easiest blocks to clean are those with paper straws. For blocks without straws, those with one size of hole are easier to clean than those with multiple hole sizes. Nests made of bundles of stems cannot be cleaned; the holes are too irregular and vary too much in dimension.

Cleaning blocks with straws

At the end of summer, use tweezers or forceps to pull out the straws. Remembering that there are live bees inside, carefully store the straws in a cool place over the winter, perhaps in an unheated but frost–free shed or garage or even a refrigerator. The straws should be in a ventilated container to minimize the growth of mold, and protected from mice. Be gentle with the occupied straws and keep them horizontal. Wash the empty blocks with a mild bleach solution (0.05%; 1 tablespoon of bleach to a gallon of water), dry them, and store them for the winter.

In the spring, do not put the occupied straws back into the blocks; instead, insert new straws to create clean nesting sites and return the blocks to their previous locations. Then, take the occupied straws from storage, bundle them, and place them in a box with a single exit hole that is one inch in diameter. Place the box near to the new straws. When the bees emerge, they will leave the box through the exit hole and should not return to the old straws. After the bees emerge, discard last year's abandoned straws.

Cleaning blocks without straws

Cleaning these nests is more difficult. It is easier simply to make new nests each year and destroy the oldest nests every three or four years. Although you will lose some bees, this strategy guarantees that parasites and diseases are disposed of. Another option is to redrill the holes every three or four years; even when done with great care, this also results in the loss of some bees.

To minimize the loss of bees before destroying or redrilling the blocks, first allow any surviving bees to emerge. Place the blocks in a larger box that has a single one–inch–diameter exit hole. When the bees emerge, they will leave the box through the exit hole and will not return. Place the box in a shady location to make it even less likely that the bees will return to nest in their natal blocks. Check the blocks occasionally; when the plugs sealing the nests are broken, the bees have emerged. You can either remove and destroy the blocks, or redrill the holes and clean them with a mild bleach solution (0.05%; 1 tablespoon of bleach to a gallon of water).

For more detailed information about cleaning nest blocks and reducing parasites, read *How to Rear Blue Orchard Bees* by J. Bosch and W. Kemp, and *Pollination with Mason Bees* by M. Dogterom.

In an increasingly urbanized nation, golf courses give a welcome break from the hard surfaces of towns and cities. Golf courses are of growing importance in many communities, offering not just recreational opportunities but also helping to maintain a clean environment.

At the core of a healthy environment are pollinators—animals that move pollen among flowers, thus ensuring that the plants can form seeds and fruits. The work of pollinators touches our lives every day through the food we eat, and even in how we mark the seasons: think of the bloom of springtime meadows, berry picking in summer, and pumpkins in the fall.

Making More Room is intended as a companion to *Making Room for Native Pollinators. How to Create Habitat for Pollinator Insects on Golf Courses*, published by the U.S. Golf Association in 2002. These guidelines expand on that document and offer easy–to–implement tips for providing habitat for native bees and butterflies.

There is a growing ethic of environmental stewardship within the superintendent's profession. Maintaining pollinator populations is one of the most valuable contributions a course can make to a healthy environment.

(Photograph by Matthew Shepherd.)

Front Cover
A female Fender's blue (*Icaricia icaricioides fenderi*) resting on a grass stem. Fender's blues are found only in the Willamette Valley, on prairies where its caterpillar hostplants—principally, Kincaid's lupine (*Lupinus oreganus kincaidii*)—grow. Both the butterfly and its hostplant are Federally protected. (Photograph by Dana Ross.)

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