USGA

Making Room for Native Pollinators

How to Create Habitat for Pollinator Insects on Golf Courses

by Matthew Shepherd, The Xerces Society

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Cover:
Flower-flies, like this drone fly, are often mistaken for bees. They play an important role as a pollinator.

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Introduction

On golf courses across the country wildflowers bloom, birds nest, mammals feed, lizards bask, bats roost, and butterflies sip nectar. Given this diversity of wildlife, it is not surprising that golf courses are recognized as being increasingly important for nature conservation. Golf courses offer comparatively stable areas within an ever-changing landscape in which wildlife can find refuge. As development and agriculture impact our environment, natural habitat in both urban and rural locations is being lost, fragmented, and degraded. In many areas, golf courses provide the only significant areas of greenspace and habitat, a resource that can support birds, mammals, reptiles, and insects. From secure places on golf courses, wildlife can spread back into the surrounding areas, replenishing and strengthening the populations that survive in the degraded landscape. In addition to this wider significance of the on-course habitats, the chance to view wildlife of all sorts adds an extra pleasure for both players and staff on the course.

Many golf courses are lovingly tended and manicured to create park-like conditions. Some golfers admire this condition, but the creation and upkeep of such landscapes demands highly intensive maintenance. The images of these park-like courses in travel brochures and on television contribute to a perception among the general population that golf courses are dead landscapes, treated with excessive amounts of chemicals. The reality is very different.

Superintendents are actively exploring innovative ways to reduce chemical inputs and to find alternative methods to maintain golf courses to the standards expected by players. There are many examples of good practice where golf course management provides high quality playing conditions, an attractive environment, and good habitat for wildlife. Golf courses offer two major opportunities for wildlife conservation: *protection* of existing areas of natural vegetation, and *creation* of new habitats in which animal and insect communities can thrive.

As with all greenspace, the value of a golf course for wildlife will be greatly increased or diminished by the decisions and actions of its managers. When properly planned and managed, a golf course can provide high quality and diverse habitat for a wide range of wildlife. Most habitat is managed is for the big, obvious wildlife, such as mammals or birds, and it is assumed that if the habitat is fine for these animals, the smaller critters will cope as well. However, by considering the details of the habitat, you can provide for the particular needs of many more creatures. These guidelines are focused on providing habitat for pollinator insects, one of the most important groups of creatures.

The importance of good stewardship of golf courses has been recognized internationally. In Great Britain, for example, the Royal and Ancient Golf Club of St. Andrews has been at the forefront of promoting better management of golf's natural heritage, supporting both innovative management and the dissemination of information. Similarly, the United States Golf Association has played a leading role in this country. Through its own publications the USGA promotes new ideas and debate, and through the Wildlife Links Program (administered by the National Fish and Wildlife Foundation) it provides grants to support research into the environmental impacts of course management and developing good management practice. Audubon International, a nonprofit that runs the Cooperative Sanctuary Program for Golf Courses encourages courses to care for wildlife. The Xerces Society benefited from a USGA grant, and with help from the U.S. Department of Agriculture Bee Biology and Systematics Laboratory, studied the conservation of native pollinators, especially of bees, on golf courses. These guidelines have been prepared as a result of that project.

Pollinators, the Forgotten Link in the Chain of Life

If you are thinking that pollinators aren't important to you directly, think again. Pollinators are profoundly important to our well-being and the health of our environment. It has been estimated that one out of every three mouthfuls of food we eat, and of the beverages we drink, is delivered to us by pollinators. In the U.S. alone, there are more than one hundred crop plants that need pollinators, without which grocery store shelves would not be so well stocked. Pollinators are also essential components of the habitats and ecosystems that many wild animals rely on for food and shelter. For example, approximately 25 percent of birds include fruit or seeds, the result of pollination, as a major part of their diet.

Pollination, the transfer of pollen from one flower to another, is a vital stage in the life cycle of all flowering plants, something that we all rely on for food and a healthy environment. Admittedly, a small percentage of plant species rely on wind (the bane of people who suffer from hay fever and allergies!) or even water to transfer pollen, but the vast majority — about 90 percent of all plant species — need the help of pollinating animals. There are many different animals that act as pollinators in North America, including hummingbirds and bats, but the most important are insects. Butterflies, moths, flies, and beetles are all valuable pollinators, but bees — especially our native bees — are the most important. Together they fulfill a critical function in our lives, but too often their presence is taken for granted and we forget that, like all living creatures, we need to care for them.

Bees, the dominant pollinators.

Bees, particularly native bees, are considered the most important group of pollinators. The reason for this is simple: female bees collect nectar and pollen from flowers to carry back to their nests as food for their offspring. In doing so they carry large quantities of pollen from flower to flower. Insects like butterflies, beetles, and flies also feed on nectar and pollen — as do hummingbirds and a few bats — but don't collect it or purposefully transport it. Some pollen gets stuck to these as they feed, and thus moved to the next flower, but this is a small amount and entirely by chance. By contrast, a single female bee may visit tens or even hundreds of flowers on a foraging trip, actively gathering and moving pollen. Both male and female bees feed on nectar, but only the female will gather forage to take back to her nest. (The life of a male bee is only to feed and mate.) Although bees have special structures on their legs and bodies in which to carry the pollen, some of it is brushed off when they visit other flowers, providing the fundamental service of pollination.

Leaf cutter bee (*Megachile sp.*) on blanket flower (*Gaillardia aristata*).

The plant communities maintained by pollinators are an important resource for other wildlife that relies on them for food or shelter. The loss of pollinators results in the disruption of plant communities in wildland ecosystems, and has serious, long-

term implications for many animal and insect populations. The impact of pollinator declines is already being seen in communities of some rare plants whose reproduction is limited by a lack of pollinators. Often these plants now rely on human intervention for their survival. For example, the fate of the rare Ute lady's tresses orchid

Sweat bees are generalists, able to exploit a wide range of flowers and survive in degraded or weedy plant communities.

(*Spiranthes diluvialis*), which grows in Colorado and Utah, hinges on adequate pollination, and the presence of the pollinators (two species of bumble bees) depends on adequate habitat. The bumble bees need secure nesting sites and a diversity of foraging plants through the summer. If these do not exist, the bumble bees will not be there when the orchid needs them. It is the responsibility of the rangeland managers to control grazing and pesticide use to ensure the right conditions persist for both orchids and bees.

The Threats Bees Face

Native bees are in decline and, in places, suffering local extinction. Like all wildlife, native bees and other pollinators are suffering from destruction of their habitat. Intensive agriculture and forestry, housing, infrastructure, and industry destroy and fragment wild areas. Pesticides have devastated pollinator populations, and pose a constant threat to the remaining populations. The native habitat that remains often is in isolated patches and is degraded by pesticides, invasive plant species, and changes in land management. Although habitat fragmentation is not as dramatic as destruction, it is a serious challenge to the survival of many bees. Native bees need both plants for foraging and suitable nesting sites. Isolated patches of habitat may have one but not the other, and thus will not be able to support viable bee populations.

Fortunately, populations of many native bees are quite resilient and can survive, though not necessarily thrive, despite habitat deprivations. Additionally, they respond well to the provision of a few of their necessary resources of foraging plants and nesting sites. Golf courses can provide an important refuge for bees and other pollinating insects. In some areas the course may be the only significant area of greenspace with relatively natural vegetation. By taking some simple steps to establish patches of native wild flowers and nesting sites, golf courses can support thriving populations of pollinators, which in turn will help maintain healthy plant communities in wild lands and support full harvest on farms and in backyards.

Gentle pollinators

When people think of bees they tend to picture a fat bumble bee or swarms of honey bees, or confuse them with yellowjackets and other wasps, and regale you with tales of being stung. In reality, these are the exceptions. It is only the bees that live in a colony or hive ("social bees," i.e., bumble bees and the non-native, European honey bee) that are likely to sting, because they have a colony to defend. Even then most are not aggressive: of the forty-five species of bumble bees in the U.S., only four or five have a feisty nature when close to their nest.

The rest of our native bees — nearly four thousand species — live on their own ("solitary-nesting") and thus have no hive to defend. To lessen the chances even further, the stinger of many species of bee is too weak to penetrate human skin, and males don't even have a stinger. When foraging away from the nest no bee is looking for conflict and will only sting (if it can) as a last resort — maybe because it is being swatted or squashed, or is accidentally caught in someone's clothes.

Since most don't fit the stereotyped *image* of a bee — black-and-yellow-striped, living in a hive with thousands of others, and apt to sting — they are easily overlooked. Out of sight and out of mind, they gently get on with the task of foraging to supply their nests, and in doing so provide the vital ecosystem service of pollination.

Pollinator conservation will not create a risk for golfers or staff. You are likely to have more problems from the yellowjackets attracted to trashcans than you will from native bees.

The Natural History of Bees

There is an astonishing diversity of native bees across North America. About four thousand species have been identified and catalogued, ranging in length from less than one eighth of an inch to more than one inch. They vary in color from dark brown or black to metallic green and blue, and may have stripes of red, white, orange, or yellow. Many common names reflect the way they build nests: plasterer bees, leaf-cutter bees, mason bees, carder bees, digger bees, and carpenter bees. Others are named after particular traits, such as cuckoo bees that lay eggs in the nests of other bee species (like the cuckoo bird), sweat bees that like to drink salty perspiration, or bumble bees, which got their name from the loud humming noise they make while flying.

Complete metamorphosis

Like a butterfly, a bee changes totally from its immature stage to an adult ("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. The egg resembles a tiny white sausage, laid on a supply of nectar and pollen left by the mother, and lasts from one to three weeks before hatching into a white, soft-bodied, grub-like larva. Whether the egg hatches as a male or female is determined by whether it is fertilized. Males hatch from unfertilized eggs and females from fertilized eggs. It is during the larval stage when most of the growth occurs. Feeding on a food supply left in the cell, the larva grows rapidly for six or eight weeks before changing into a pupa.

During this apparently dormant stage, which may last eight or nine months, the bee transforms into its adult form within a protective cocoon. When they emerge from this, the adult bees are fully-grown and ready to mate and continue the cycle. Most adults are active for three or four weeks, the females working hard to make and supply a series of egg cells for the next generation.

Bees can be divided into two groups by their lifestyles: social or solitary. Despite the fact that the popular image is of a bee living in a hive, only a very few species of bees are social. Social bees live in a colonial nest, have contact between generations, and share the work of building the nest, caring for the offspring, and foraging for pollen and nectar. The truly social bees in the U.S. are the non-native European honey bee and the bumble bees (about forty-five species). In general, the rest of the nearly four thousand species of bees in the U.S. are solitary nesting. They create and provision a nest on their

own, without cooperation with other bees. Although they often will nest together in great numbers when a good nesting area is found, the bees are only sharing a good nesting site and not cooperating. Inevitably, there are exceptions that prove the rule: a few "solitary" species are known to share a nest, share the work inside the nest, or even, in the case of large carpenter bees, have contact between the mother and her offspring. These are grouped as solitary bees as, quite literally, there are only a handful of bees in a nest and none of the rigid colony structure of the social bees.

Solitary nesting bees

Solitary bees generally live for about a year, although we normally only see the active adult stage of its life, which usually lasts for only three or four weeks. These creatures spent the previous eleven months growing through the egg, larva, and pupa stage in the brood cell or nest.

During its brief adult life, the bee is focused on successful reproduction. The male bee will hang around nesting areas or foraging sites hoping to mate with a female. The female bee will mate once — she stores the sperm and releases it when needed — and then spends her time creating and provisioning a nest in which to lay her eggs. Female native bees have amazing engineering skills, and go to extraordinary lengths to construct a secure nest. In natural conditions, solitary bees will nest in all sorts of places. A few species construct domed nests out of mud, plant resins, saps, or gums along with tiny pebbles on the surface of rocks or trees. Others will even use empty snail shells. About a third of bees use abandoned beetle burrows or other tunnels in snags (i.e., dead or dying standing trees) or excavate their nests within the soft central pith of stems and twigs. Most species, however, nest in the ground, digging a tunnel in bare or partially vegetated, well-drained soil. Sadly, a human desire for tidiness often means snags are removed and bare soil is covered, resulting in the loss of these and other suitable nesting places.

Each bee nest usually has several separate brood cells in which the female will lay her eggs. The number of cells varies according to the species. Some nests may have only a single cell, but most have more, often ten or more and, occasionally, in excess of sixty. These cells may be in a single line filling the hole or burrow, but many ground-nesting species dig complex, multi-chambered tunnels. Most species line the cell to protect the developing bee, sometimes with a polymer-like secretion, but often the interior is just made smooth by the bee. The bees that make cells in lines typically nest in holes in plants or trees, and use a cap of plant materials or soil to close each cell and separate one cell from the next. For example, leafcutter bees neatly trim leaf pieces from broad-leaved plants and use them to line their brood cells, cutting different sizes and shapes for different parts of the cells. Mason bees typically use mud or leaf pulp to seal their nests.

Before she closes each cell, the bee must provision it with food for her offspring. She mixes together the nectar and pollen she collects to form a loaf of "bee bread," which she places 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. After the eggs hatch, each larva feeds on the bee bread inside its cell until it changes into a pupa. After a period of inactivity, it will finally emerge as an adult and begin the cycle again.

To get the food back to the nest, most bees carry nectar in their crop (a special sac-like chamber in their digestive canal), but how they carry the pollen depends upon the

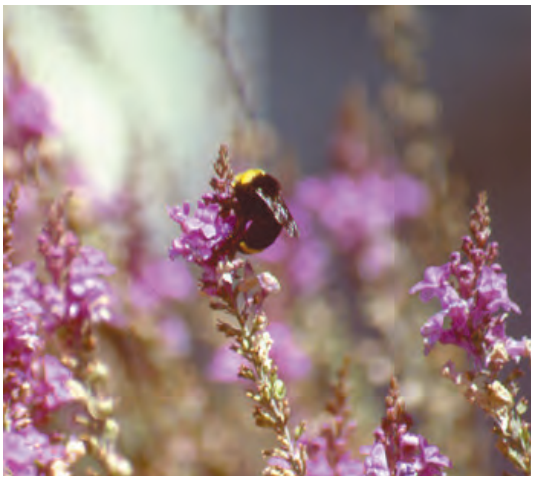
species. Most solitary bees have an area of stiff hairs, called a pollen brush or scopa, into which pollen grains are pushed. These hairs are located either on the underside of the abdomen or along the hind legs. In a few species the scopa extend from their legs onto their bodies. A few species don't have scopa and carry pollen in their crop, probably alternating between pollen and nectar on separate foraging trips.

Solitary bees can be divided into two loose groups according to their foraging habits: generalists and specialists. *Generalists* are bees that gather nectar and pollen from a wide range of flower types and species. Often these are the more resilient species, able to survive in degraded environments with weedy or non-native plants. *Specialists*, on the other hand, rely on a single plant species or a closely related group of plants for pollen (they are usually less choosy about sources of nectar), and are more susceptible to landscape or habitat changes. The life cycle of these bees species are often closely tied to their host plant, and the adults will often emerge from their brood cells just when the plant is flowering.

Bumble bees

Bumble bees are the only bees native to the U.S. that are truly social. They live in colonies, share the work, and have multiple, overlapping generations through the spring, summer, and fall. However, unlike honey bees, the bumble bee colony is seasonal. At the end of the summer most of the bees die, leaving only a few fertilized queens from each nest to hibernate through the winter. In the spring, each surviving queen will found a new nest that eventually may grow to include dozens of individuals, occasionally a couple of hundred.

Bumble bees need a cavity in which to nest. The queens are opportunists, looking for any suitably sized cavity. Sometimes this is above ground, such as in hollow trees or walls, or under a tussock of grass, but mostly they nest underground. An abandoned rodent hole is a favorite, as this space is warm and already lined with fur. The queen creates the first few brood cells from wax, lays eggs, and then provisions them with pollen and nectar as the larvae develop. It will take at least a month for her to raise the 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. The queen will continue to lay eggs, so the colony will grow steadily through the summer. At the end of summer, new queens and drones will emerge and mate. As the cooler weather of fall arrives most of the bees, including the old queen, will die, leaving only the new, mated queens to overwinter.



A harbinger of spring in the western United States, yellow-faced bumble bee (*Bombus vosnesenskii*) queens emerge from hibernation when willows flower.

They are generalist feeders, often the first bees active in late winter (February) and the last in fall (November). To support a colony all season, they must be able to forage on a wide range of plant species, in a wide range of weather conditions. Some individual bees in the colony, however, choose to forage exclusively on a single species or a limited range of related plant species, effectively becoming specialist foragers. When foraging, the female bumble bee carries pollen in a

concave, hairless area surrounded by stiff hairs on her rear legs, known as the pollen basket or corbicula. This basket can be seen clearly when it is empty and, when full, the pollen ball pressed into it is obvious.

Bumble bees also differ from solitary bees when feeding their larvae. They provide food gradually, adding it to the brood cells as the larvae need it ("progressive provisioning") rather than leaving all the food in the cell before laying the egg. In addition, bumble bees do make a small amount of honey, just enough to feed the larvae and themselves for a couple of days during bad weather.

Cuckoo bees

A number of bee species do not make their own nest and, instead, lay their eggs in cells prepared by another species of solitary or bumble bee. These cuckoo bees are not true parasites, as they do not feed on the host bee — although they do kill the larva in the cell, so they can get all the food — but cleptoparasites, as they grow from egg to adult by feeding on the provisions provided by the host species.

Typically, cuckoo bees that prey on solitary bees enter the nest to lay eggs while the host is out foraging. Cleptoparasites of bumble bees, however, have to enter an established colony full of workers. Sometimes they will fight to the death with the existing queen and sometimes they'll hide in the nest until they take on the same smell as the host colony. Once accepted by the colony the invading cuckoo bumble bee will take over the role of queen, laying eggs which the workers tend.

Helping the Forgotten Pollinators

Sympathetic management of out-of-play areas can provide excellent habitat that will benefit pollinator insects, as well as many other types of wildlife, and it is these areas

Two things that bees need are flowers for nectar and pollen and nesting sites, like the asters and the wooden block shown here.

of golf courses that these guidelines are focused on. Of course, if there are other places on your course that could be suitable for pollinator conservation, the information presented here will help, too. There are several features of golf courses that make them good for habitat creation and management, not the least of which is that they are relatively undisturbed. They also have full-time maintenance staff, some resources, and a significant acreage of land that is mostly protected from development and other intrusions.

There are three simple things that can be done to improve golf courses, or indeed any greenspace, for native bees and other pollinator insects. Good native bee habitat has two necessary components:

- *foraging habitat* with a range of native plants to provide nectar and pollen through the seasons, and

- *nesting sites* with suitable ground conditions or lumber, and appropriate nesting materials.

The third step is to *avoid using pesticides*. Insecticides directly kill bees and herbicides kill plants, reducing the diversity of foraging habitat available. It is unlikely that pesticides will be used in out-of-play areas, though there may be some limited use during the establishment of new pollinator-friendly plants. Wherever possible, use an alternative technique to control competitive plants in pollinator habitat.

By simply adding native plants to out-of-play areas you will help local pollinator populations. Butterflies, flower flies, and other beneficial insects (such as nectar-feeding beetles) will forage in the same habitat as bees. But for native bees to benefit fully, both foraging plants and nesting sites should be created. Bees, like butterflies, need different conditions as adults and young. An adult butterfly, for example, will sip nectar from almost any flower, whereas the caterpillar needs the right plant to munch on, and is often very specific about the species. Similarly, with bees, the adult feeds and forages on flowers but it also needs a suitable place to make a nest in which the larvae will develop.

These guidelines have been written to help you plan and manage out-of-play areas for beneficial, pollinating insects. They do not attempt to give great detail about specifics of plant care, as many excellent sources of information are already available. In addition, every golf course has different soils or climate, unique growing conditions that the staff will understand better than anybody else.

Managing sites for native bees should not be confused with beekeeping: there are no hives, no need for special safety equipment, and there is no reason to handle any bees (although you can safely hold nesting blocks for native bees without any risk of being stung). Creating habitat for native bees is just a case of ensuring the right flowers and nesting conditions are there. After that you can sit back and watch the bees work!

Creating Foraging Habitat

In some ways, the ideal approach to creating a natural area is simply to leave it alone and let Nature do her stuff. This tactic can work well in places where there is a neighboring source of appropriate seed, and enough time. In most situations, however, you will need to use plants or seed to create the foraging habitat pollinators need. Growing a native plant is like growing any other plant: it will need to be planted, and then require watering and weed control. Since it should be well adapted, a native plant is often better able to cope with the conditions and requires less care than a non-native species.

Flower-rich areas will provide nectar and pollen for a wide range of beneficial insects.

Choosing the Right Flowers

Foraging habitat should contain a range of plants that will provide a succession of flowers, and thus pollen and nectar, through

the whole growing season. Foraging plants can be introduced to a golf course by creating either natural habitat in out-of-play areas or flower borders in more formal parts of the course, such as by the club house or golf shop. Native plants are frequently the best choice for both of these approaches, as they are usually better adapted to grow in the climate and soils of your region. In addition, there are many garden plants that are North American natives, such as black-eyed Susan, Joe-pye weed, and coreopsis, which are wonderful pollinator plants. They may not be native to your region, but mixed with garden plants — particularly older varieties of perennials and herbs that are good sources of nectar or pollen —

Bumble bees are generalist foragers, visiting a wide range of flowers to feed and gather nectar and pollen. This Sonoran bumble bee (*Bombus sonorus*) is foraging on stick-leaf blazing star (*Mentzelia pumida*).

these can be used to create attractive flower borders. Such non-native plants should not be used in out-of-play areas, as they can be invasive and cause problems in natural areas.

In a publication of this length it is not possible to give detailed regional lists of suitable plants. Included are two lists of pollinator-friendly plants. Table 1 lists native plant genera and table 2 garden plants, both native and non-native. Used with the notes below, they will help you choose appropriate plants. A native plant field guide to will tell you which species from these genera in table 1 occur in your locale. Your local chapter of the Native Plant Society, county office of the state Cooperative Extension Service, and native plant nurseries are worthwhile contacts for advice on choosing, obtaining, and caring for local plant species. Most are happy to advise on all aspects of designing and planting enhancement schemes. Some city councils have lists of plants native to their area or botanists who can advise you. Your local telephone directory will list contacts for most of these, or check the web site of the Lady Bird Wildflower Center (see the list of organizations in appendix B), where you will find state-by-state listings of wildflower organizations and other resources.

When you are planning habitat enhancements, the main points to consider are:

- **Use local native plants.** Local native plants are usually well adapted to your growing conditions, can thrive with minimum attention, and are good sources of nectar and pollen for native bees. Horticultural varieties and hybrids, in contrast, are not necessarily suited to local conditions, and may have been bred to produce showy blooms at the expense of nectar or pollen production. When obtaining native species, always ask where the seed originates. Often plants sold as native are not from local sources, and thus may not give you the full benefits of easy growing and pollinator forage.
- **Choose plants with a diversity of color.** Bees have good color vision and can see as wide a range of colors as people. The difference is that bees see in a spectrum shifted towards blues and ultraviolet, i.e., we see from red through orange and the rest of the rainbow to violet, and bees see from orange through the rainbow to violet

and then into ultraviolet. To a bee, what we see as red appears black. In practical terms, this means that for bees good flower colors are blue, purple, violet, white, and yellow. (Red will attract butterflies and hummingbirds.) Since we cannot see ultraviolet, we cannot choose UV flowers, though many flowers have UV markings that help guide bees to the nectar.

- **Choose flowers of different shapes.** Bee species are all different sizes, have different tongue lengths, and, consequently, will feed on different shaped flowers. There is a rough correlation between the depth of the flower tube and the length of the tongue of the bees that use them. Some flowers, like aster, are very open and the nectar and pollen is readily accessible to insects of all sizes or those with short tongues. Others, like lupines and penstemons, have nectar that is harder to reach and are preferred by robust bees that can push between the petals or those with longer tongues. A range of flower shapes means more bees (and other insects) will be supported.
- **Have plants flowering all season.** Most bee species are generalists, so a diversity of plants provides a supply of nectar and pollen through their life cycle. Bees can be seen anytime between February and November — maybe longer in mild climates — so a sequence of plants providing a diversity of flowers through the growing season will support a range of bee species with different flight periods. The social-living bumble bees may be out foraging all season, whereas the emergence and active life of many solitary-nesting bees is synchronized with the flowering period of forage plants. The active season for bees is influenced by the climate, and so will vary from region to region. For example, in deserts, it is primarily linked to rainy seasons when the flowers bloom, and in mountains, to rising spring temperatures so it is warm enough for bees to fly. In general, when flowers are naturally blooming, bees will be active.
- **Include both perennials and annuals.** Given the huge diversity of native bees, it is not surprising that there are some that prefer foraging on perennials and others that prefer annuals. Research shows that some families of bees tend to forage more on one type or the other. The small, short-tongued andrenid bees, for example, take nectar mostly from annuals, the colletid bees will forage on either, and the large, long-tongued anthophorid bees and bumble bees forage mainly on perennials. Including both annuals and perennials in your choice of plants will thus support more bees.
- **Look at the likely habitat area.** The environmental conditions of the chosen habitat area will influence the choice of plants. It is obvious that sun-loving prairie plants will not like being planted in the shade of trees, nor will shade-dwelling forest plants thrive in the sunny exposure of a prairie, but it is often less obvious when small-scale changes in soils, slope, exposure, and moisture have significant impacts on what will grow. One principle to keep in mind is that a plant community designed to suit existing site conditions should be simpler and less expensive to establish and maintain than changing the local conditions to suit a plant community.
- **What is growing already?** A survey of wild plants growing in similar conditions can be valuable for planning, especially if the area contains original vegetation. This will guide you to which plants are local and indicate plants suitable elsewhere on your course.
- **Growth habit.** How large, how spiky, or how dense the plants grow may also be a factor in which plants to chose. The course

should remain playable. Some native plants may be considered inappropriate as they can interrupt the game (for example, thorny plants may not be good if players have to walk through an area to search for stray balls). Similarly, dense ground cover can make lost balls harder to find. The solution could be to restrict such plants to out-of-play areas, and introduce golfer-compatible plants elsewhere. (Or restrict players from entering pollinator habitat.)

- **Avoid invasive species.** Species that are known to be highly competitive, strong growing plants, or those that spread quickly and easily from seed, suckers, or rhizomes should be avoided. They are likely to spread and dominate the other species, reduce the diversity and value of the habitat, and increase maintenance demands. They also may spread beyond the habitat patches and cause problems elsewhere on the golf course. Check with your local city, as some have code restrictions on certain noxious weed species.
- **Avoid rare species.** There is often a good reason for a species being rare, such as very specific conditions for establishment or a particular habitat requirement (or no pollinators!), which will make them difficult to grow. Of course, if you believe you can provide the greater management input or specialist knowledge for rare plants to survive on your golf course, then consider planting them.
- **Think ahead to what the habitat will look like in the future.** Planning five or ten years ahead will help guide plant choices, as it will allow you to consider the likely maintenance.

Table 1. Native plants for bees and other pollinator insects.

The plant genera listed below are all good sources of nectar and/or pollen. Talk to your Native Plant Society or a native plant nursery in your local area to identify species from these genera appropriate for your region.

(Note: This list covers genera from all regions of the country, so some of the named genera may not be native to or grow successfully in your area.)

Common name	Genus
yarrow	*Achillea*
giant-hyssop	*Agastache*
wild onion	*Allium*
aster	*Aster*
Oregon grape	*Berberis*
brodiaea	*Brodiaea*
rabbit-brush	*Chrysothamnus*
clarkia	*Clarkia*
shooting star	*Dodecathon*
buckwheat	*Eriogonum*
blanket-flower	*Gaillardia*
geranium	*Geranium*
avens	*Geum*
gilia	*Gilia*
sunflower	*Helianthus*
flax	*Linum*
lomatium	*Lomatium*
lupine	*Lupinus*
evening-primrose	*Oenothera*
cholla (prickly pear)	*Opuntia*
penstemon	*Penstemon*
phacelia	*Phacelia*
currant, gooseberry	*Ribes*
wild rose	*Rosa*
willow	*Salix*
skullcap	*Scutellaria*
stonecrop	*Sedum*
groundsel	*Senecio*
goldenrod	*Solidago*
globe-mallow	*Sphaeralcea*
snowberry	*Symphoricarpos*
mullein	*Verbascum*

Table 2: Garden plants for bees and other pollinator insects

This list of garden plants includes some North American native plants. These would be suitable for flower borders, but not for inclusion in areas of native habitat, except in the areas within their natural distribution. When choosing plants, avoid varieties that are improved or hybrids. Often these have been bred for the size or color of flowers at the expense of nectar or pollen production.

Common name	Genus
giant hyssop	*Agastache*
borage	*Borago*
paint brush	*Castilleja*
wild lilac	*Ceanothus*
bee plant	*Cleome*
cosmos	*Cosmos*
globe thistle	*Echinops*
wallflower	*Erysimum*
Joe-pye weed	*Eupatorium*
blanket flower	*Gaillardia*
sunflower	*Helianthus*
hyssop	*Hyssopus*
English lavender	*Lavandula*
purple gay-feather	*Liatris*
purple toadflax	*Linaria*
mint	*Mentha*
four o'clock	*Mirabilis*
bergamot (bee balm)	*Monarda*
basil	*Ocimum*
marjoram	*Origanum*
poppy	*Papaver*
rosemary	*Rosmarinus*
sage	*Salvia*
skullcap	*Scutellaria*
thyme	*Thymus*
mullein	*Verbascum*
verbena	*Verbena*
zinnia	*Zinnia*

Where to plant

Encouraging more bees and other pollinator insects onto your golf course by creating habitat will not increase the risk of golfers being stung. Despite this, there often will be resistance to the creation of bee habitat. Fortunately, the chance of conflict between players and bees is low, as many places on a golf course where people usually go are unlikely to be appropriate for bee conservation. When planning habitat improvements a survey of the golf course and time spent watching golfers to see where they most frequently go will identify suitable sites. Here are some things to consider during this process:

- **Playing areas.** The principal playing areas are obvious places that are inappropriate for active pollinator conservation. Tees, greens, and fairways are all managed carefully to provide specific conditions for different aspects of the golf game, creating a landscape that is unlikely to attract many pollinators. Consider using roughs and out-of-play areas to encourage pollinating insects.
- **Course layout.** The layout of the course and slope of the fairways may mean some roughs or out-of-play areas are more likely to have balls hit into them. (For example, the outside of a bend in the fairway, the inside edge of a dog leg, or the lower side when a fairway has a cross slope.) These areas may be suitable for pollinator plantings from an ecological perspective. However, because they will have more golfers walking or driving through them to find and play their balls, they are likely to become a point of concern to golfers and, thus, may not be appropriate sites for planting bee forage.
- **Topography.** Topography influences the habitat by changing drainage rates, moisture levels, sun aspect, and wind exposure. For instance, south-facing areas are usually warmer, creating better

foraging conditions for sun-loving bees. Similarly, drier, warmer places are often preferred by ground nesting bees. During rainfall check the drainage of potential habitat areas, noting where runoff collects or flooding occurs. If you already have an area in mind for enhancement, mark which parts flood or saturate, and which are well-drained or stay dry.

- **Existing habitat.** Look for existing areas of good habitat, as these patches are likely to support pollinators already. The pollinators will benefit directly and swiftly from expanding or enhancing these habitat patches, linking them to other patches, or changing the management regime of adjacent areas.

Many courses already contain good habitat, which can form the basis for a network of pollinator areas across the course.

- **Location of trees.** The presence of trees can have two effects: creating shade and acting as a windbreak. In hot areas shade is unlikely to be a major issue, though you'll want to avoid places that are shaded in the morning for nesting habitat. Trees as a windbreak can improve a foraging area.
- **Size of habitat patches.** There is no simple answer to how big the habitat patch should be. The best advice is to make habitat patches as big as possible, and create as many as you can. Foraging habits of many bee species have not been studied, and it is not known for sure how big their home range needs to be. Some bee species have been recorded going no more than a couple of yards from their nest to gather nectar and pollen, others half a mile or more. Most probably travel less than a hundred yards from their nests. Bigger patches will generally be better for wildlife, providing a site that is more likely to support stable plant and animal communities. For bees, bigger patches are definitely better as they offer a better chance that there will be both sufficient foraging plants and a nesting site.
- **Shape of habitat patches.** Whilst any habitat area can be beneficial, the less disturbed it is the better. Narrow or linear areas will be more disturbed, as activities at the margins (for example, from mowing adjacent grass or players moving between holes) will impact proportionately more of the habitat. Big and blocky shaped patches are a good idea, giving the maximum habitat area for the minimum edge length.
- **Habitat corridors.** Fragmentation of habitats has been a significant problem in recent decades, so where possible, link habitat patches with continuous strips of natural vegetation. Joining patches together will increase their effective size by allowing wildlife to move safely between individual patches.
- **Accessibility of habitat areas.** The habitat areas must be accessible for planting and maintenance. Although in the long term maintenance should be minimal, in the establishment period access will be needed to provide weed control and irrigation (although irrigation can be reduced by using locally native plants).
- **Visibility of the habitat.** On some courses, not all golfers will appreciate having a habitat area in a prominent location. To

some a flower-rich prairie is a beautiful sight, to others it is an untidy eyesore. However, ensuring that the habitat is visible to players also advertises the fact that the course managers have a commitment to a healthy environment and that caring for it is an integral part of course management. Habitat areas can be of great educational or interpretive value, giving an opportunity to inform players how the course is managed and highlight the benefits gained from wildlife management.

- **Rare plants or wildlife.** If you already have rare or unusual wildlife on your course be wary of modifying its habitat. For example, unless the ecological requirements of rare plants are understood and can be assured after any management action, altering the habitat could jeopardize their survival. This applies also to rare animals, as altering the habitat (i.e., plant communities) they rely upon for food and shelter might affect their continued presence on the course. Additionally, there may be regulations or legislation that protects both rare species and their habitat. In short, be careful when dealing with the habitat of rare plants or wildlife.

What to plant?

When you have decided which species to plant, the next step is to decide how many plants you'll need and what type of planting material to use, pot-grown transplants or seeds. It is likely that in most situations you will be adding plants into existing vegetation. For this, pot-grown transplants are far better, as they are better able to survive competition from existing plants and you will get a much higher survival rate. Seeds, in contrast, are much more difficult to introduce into existing grassland, as the current plants will out-compete the seedlings, and are best used on the bare ground of new or remodeled golf courses.

Sometimes, you may only be able to get seeds for the species you want. If this is the case, it may be best to plant the seeds in pots and grow your own transplants.

Occasionally, alternative sources of planting material are available. For example, if a nearby area of habitat similar to the golf course environment is being lost to development, removal of natural sod or plants may be possible. Translocation of plant materials has mixed success and, often, the relocated plants die. Habitat is damaged by the removal of plants or sod, so it should not be considered unless the donor habitat is going to be destroyed and this is the only way that fragments can be saved. The creation and management of habitat on golf courses should be done in addition to, and not at the expense of, existing areas.

Deciding how many plants

Calculating how much grass seed to use is a well established and tabulated decision-making process, but deciding how many native plants to use is less straight forward. The ideal outcome is to have enough plants to create a self-sustaining plant community. In the short-term, there may be losses due to poor planting or a lack of watering. In the medium-term, animals like rabbits or snails might eat them. In the long-term, a small or isolated population could lead to a loss of genetic diversity, a weakening of the plant community, or even loss of all the plants.

- **Minimum population size.** The ideal target is to establish a native plant community that has enough individuals of each species to be self-sustaining, with each species producing sufficient seed to ensure the future of the community. In simple terms, if the species is perennial then you will need a smaller number of plants than if it is an annual. Research suggests that the minimum population needed to ensure a stable plant community

ranges from as few as fifty plants for some herbaceous perennials, to several hundred for some annuals. In your habitat areas you may not be able to achieve these "ideal" numbers, but try to establish as many plants as possible.

- **Planting density.** The choice of transplants or seeds will influence how much plant material you will need. With transplants, plan for one perennial every 18 inches within the habitat area (approximately four plants for every square yard of habitat) and annuals at a higher density of one every 12 inches (nine plants per square yard). Sowing flower seeds on bare soil will require a much higher density of between five and ten flower seeds per square foot (up to ninety seeds per square yard) for each species, mixed in with native grass seeds. (See pages 17–18 for more information.)
- **Distribution.** These plant populations do not necessarily have to be in a single habitat patch. If habitat areas are not too far apart (less than about 50 yards), populations of plants can be spread between two or three patches. Perennials, which live for several years and are able to cope with changing conditions, are more likely to thrive with a divided population. Annuals, in contrast, need to create seed for the next generation of plants within the first summer. To ensure adequate pollination between plants, the populations should be close together.

Establishing and Growing Pot-grown Transplants

Pot-grown transplants are the most suitable planting material to use when adding plants to existing vegetation. The following suggestions will help you achieve higher plant survival rates:

- **When to plant.** In most areas, perennials can be planted during the fall or spring. Desert areas may be different, as the rainfall seasons will dictate the best time for planting. In general, fall planting is better, particularly for spring-flowering species. This gives time for roots to get established before the growing season and will make plants more resilient to dry summer conditions, reducing the need for supplemental irrigation. In regions with long, cold winters, however, spring planting may be better, as frost heave may push plants out of the ground. The natural rainfall pattern in your region will also influence planting time. Plan planting so the transplants will benefit most from the available rainfall.
- **Site preparation.** Remove the worst weeds. Areas of bare soil may create a bad weed situation for the future, so avoid clearing all vegetation. The advantage of using transplants is that they can be introduced into an existing vegetation cover, which helps to suppress weeds.
- **Planting pattern.** Assuming you wish to create a natural-looking area, avoid planting on a strictly measured grid with regular spacing and straight lines. Distribute the plant species randomly across the habitat area, planting clumps of individual species containing five or six plants.
- **Irrigation.** Adequate water during the first summer is critical. Planting in fall will reduce the need for irrigation, as the plants will have had time to develop larger, deeper root systems, which are better able to survive the first summer without irrigation. Irrigation, especially sprinkler systems that wet the surface, will benefit weeds too, so minimizing the need for irrigation will also help to reduce weed problems. When planting annuals or spring-planted perennials, a general guide is to irrigate at least once a week for the first six weeks. After that, water as needed. These guidelines are not region-specific and

irrigation regimes will need to be adapted to local soil, topography, and climate. Mulching the soil surface in the first year after planting can help to retain moisture and reduce the need for irrigation. Irrigation of perennials in subsequent years should not be necessary — unless a drought is going to kill the plants — as this additional water can encourage root development close to the surface, making the plants more susceptible to damage by dry spells, and impede the growth of the deep roots the plants need.

- **Weed control.** Weeds compete for light, nutrients, and water, and will stunt or even kill desirable plants. Lack of weed control is one of the most common factors causing poor establishment of plantings. Mulching the newly planted area will help to suppress the growth of unwanted plants, but is unlikely to provide complete weed control. Herbicides may damage the transplants. The only effective method may be to hand weed around the transplants, pulling up perennial weeds and pulling or cutting annuals before they go to seed. Waiting until annuals are flowering before weeding can be effective, as plants have put all their energy into growing and flowering, and may have little time or energy left to re-grow.

Irrigation and weed control are the two most important maintenance tasks for newly planted areas.

Using wildflower seed

The creation of wildflower-rich grassland is easily integrated into course construction or remodeling. This can cheaply and swiftly produce large areas of species-rich turf. The points below will guide you when doing this. This approach may also be used to grow species-rich sod, very much as you might grow turf in a putting green nursery, ready for transfer into the habitat areas. Once in place, it will provide a reservoir of native plants that can spread through the surrounding area, although this can be a slow process.

- **Seed mix.** Natural prairies often have dozens of species, but for a new area a seed mix containing fifteen to twenty species of native grasses and forbs will be enough. Between 50 and 80 percent of the volume of the seed mix should be made up of four or five species of native grasses, which could include a fast-growing annual species as a nurse crop. A seed mix of this diversity will give a good foundation from which a richer habitat can develop through natural colonization or enhancement with transplants in future years. Choose forb species that will give a range of flowering times through the seasons, and a variety of flower colors and shapes. Your native plant seed provider or Native Plant Society chapter can probably advise you on which species and how many seeds you'll need.
- **Site preparation.** The seedbed should be tilled and treated for weeds. If the site is prone to erosion, soil conservation measures should be incorporated into the plan. Soil protecting polymers or straw mulch can be added after seeding to stabilize the soil. If the site is near a water body, erosion fences to stop soil washing into the water may be required by local environmental codes, and should certainly be installed as a matter of good practice.

- **Seeding.** The actual method of seeding will depend on a number of factors, including site location, topography, and size. For small areas, broadcasting by hand is often the best, and simplest, method. For larger areas a seed drill or hydro-seeding may be necessary. After seeding, rake or harrow the area.
- **Irrigation.** As with transplants, irrigation of seeded areas is vital during the first summer.
- **Weed control.** Weed control may be required for two or three years depending on the rate of establishment and growth of the newly planted seeds. Once the new species-rich turf is established it should be dense enough to suppress annual weeds, though some regular maintenance will be needed to control noxious or invasive species.

Habitat management

Depending on the type of vegetation community created, you may have to undertake management of the habitat areas. In many areas, untended prairie plant communities left will develop into scrub or forest if they are not cut or burned periodically to maintain the open, sunny conditions. If the area is cut, the cuttings should be removed. Leaving them on the ground can smother plants and, over time, will lead to a build-up of nutrients that can favor stronger growing, weedy species instead of the desired natives, resulting in a loss of diversity. Cutting or pulling unwanted shrubs could check their spread. (Treat the stumps to prevent re-growth.) Don't cut or burn the whole area in one go. A wide range of insects, including butterflies, beetles, and bees, lay eggs on or overwinter inside plant stems. A two or three year rotation ensures that all areas get cut and yet maintains patches of suitable overwintering habitat.

During the planning stage of the habitat areas thought should be given to what you want the area to look like in the future (for example, ten years ahead). With this in mind, plants should be chosen that will be simple to manage and resources should be identified to support the management of these habitats. Conservation and habitat work may be of interest to golfers, other local volunteers, or scout groups (for instance, Eagle scouts often need projects for badges). These groups should be kept in mind, or approached, when planning habitat improvements.

Bee nesting sites

There are several simple ways in which nesting sites can be made for bees. Here we describe how to make a variety of nest types for both ground- and wood-nesting solitary bees, and bumble bees. Many of these methods mimic natural features, such as beetle-bored snags, patches of bare ground, or old walls that no longer exist in modern landscapes. As with many aspects of conservation, the wider the range of conditions you create, the greater the diversity of species you could attract. However, not all nest types described below will be suitable for your golf course. Walls made from adobe blocks, for example, may not last long in a rainy climate.

Location of the nesting sites is important. Most ground-nesting bee species will avoid wet soil, so choose areas of dry, well-drained ground, preferably south or southeast facing. (Some species line their brood cells with a waterproof membrane, so can nest in riparian areas that flood occasionally.) In damper areas, the addition of sand piles or other raised soil can dramatically improve the conditions for bee nesting, but not if the site will have standing water that could soak up into the piles. Wood-nesting bees prefer sites that are sheltered from the worst of the weather, with entrance holes facing towards the east or southeast, so they get the morning sun. Most bees cannot heat themselves efficiently, and need the

Combining nesting sites with foraging areas will create good native bee habitat.

sunshine, especially in the morning, to provide enough warmth so they can become active.

The nesting sites should be in or close to areas of foraging habitat. Many bee species cannot fly long distances, so will not use nests if they are isolated from foraging habitat. In addition, if foraging habitat is separated from nesting sites, bees may expend more energy flying than they gain from feeding. If you create the right conditions, bees will begin to use the nests, often only days after you finish them.

Nesting sites for ground-nesting bees

Most native bees nest in the ground. The requirements of some species are so well understood that artificial nesting sites are created commercially to provide reliable crop pollination. The alkali bee as a pollinator of alfalfa is the best known example. For others, the precise conditions to attract particular species are not known. The methods outlined below will allow you to create ground conditions and establish sites suited to a diversity of species.

- **Bare ground.** Simply clear the vegetation from a small (about 6 feet by 6 feet) level or sloping area, and gently compact the soil. These areas should be well drained, in an open, sunny place, and, where possible, on a southeast-facing slope. A few rocks placed in the cleared area will improve it by adding basking places. In addition, these rocks help to warm the soil by absorbing and retaining the sun's heat and by reducing air movement, and its consequent cooling, along the ground's surface. Inevitably, different ground conditions — from vertical banks to virtually flat ground — will draw different bee species, so create several different areas within your habitat.
- **Sandpit.** Dig a pit about 12 feet square and 3 feet deep, and fill it with fine-grained, pale-colored sand, or a mix of loam and sand. The pit must be able to drain, otherwise the nests could flood. As with areas of bare ground, the sandpits should be in sunny places.
- **Sand pile.** Where soils do not drain well, a sand pile or raised bed (contained by walls of lumber or bricks) of similar sand or sand/loam mix as the sandpit, but only about 2 feet high, can create suitable nesting conditions.
- **Adobe blocks.** A wall about 4 feet high and 6 feet long made from adobe blocks also can provide warm, dry nesting sites. Use wood and/or metal backing and supports to prevent the blocks from toppling. The front of the wall should face towards the east or southeast. In this face, drill holes in a range of diameters between 3/32 inch and 3/8 inch as deep as you can — at least 4 inches for the larger diameter holes — into the blocks.

Nesting sites for wood-nesting bees

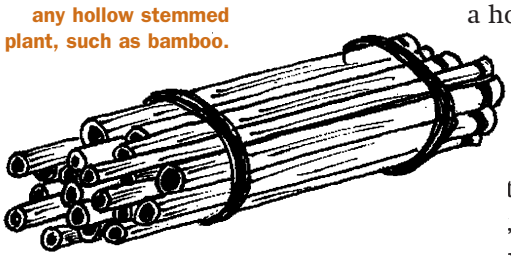
Many bees, such as leafcutters and masons, naturally nest in beetle tunnels in snags and similar holes. Information about one of these, the orchard mason bee, is widely available, particularly the size of nesting hole they prefer (5/16 inch diameter). There are many other bees that will nest in drilled holes (including other species of mason bee), but they prefer other hole sizes. When making wooden nest blocks or the other types of nest described below, providing a range of hole sizes will support a wider range of bee species that will forage and pollinate over a longer season than just the orchard mason bee, which, in most areas, is active only between late March and early May.

- **Logs and snags.** Get some logs or old stumps and place them in sunny areas of the habitat patches. Plant a few upright, like dead trees, to ensure some deadwood habitat stays dry. On the southeast side of each log, drill a range of holes, as with the adobe blocks, between 3/32 inch and 3/8 inch diameter and as deep as you can (at least 4 inches deep for the larger diameter holes). When drilling, make the interior of the holes as smooth as possible. Bees are not partial to rough holes and may avoid them.

- **Twig bundles.** Elderberry stems, with their soft central pith, are naturally used by some bee species, and can easily be used to create nesting sites. Cut the stems into 8 inches to 12 inches lengths. From one end, drill out the central pith to form a hole 3/32 inch to 3/8 inch diameter to a depth of up to 6 inches, ensuring that the opposite end stays closed off. Tie tems in bundles of fif-, and fix the bundle to a stake or tree with the stems horizontal to the ground. Other plants whose stems have a soft pith or are hollow can be substituted, such as blackberry, raspberry, sumac, bamboo, or teasel. Hollow stems are really easy, as you only have to cut and tie the bundles. When cutting, be careful to cut close to a stem node. This will leave a tube with one end open and the other closed.

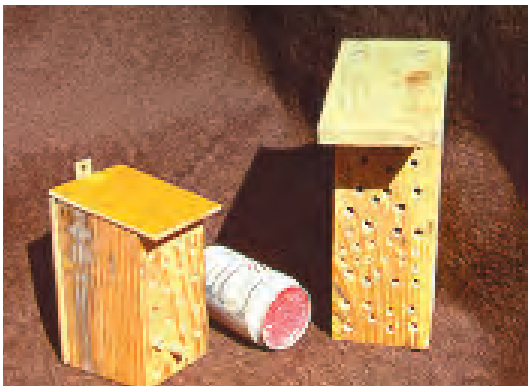
Make bundles of 15 to 20 lengths, with the open ends facing the same way, and tie with string, wire, or duct tape.

This can be done with any hollow stemmed plant, such as bamboo.

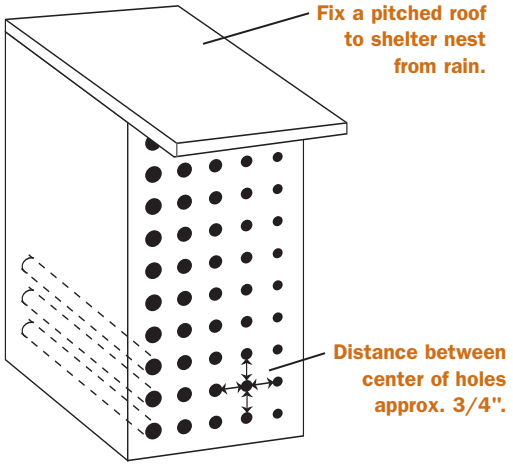


- **Elderberry stakes.** Cut elderberry stems into stakes, between 24 inches and 30 inches long, and sharpen one end to make it easier to push into the ground. Drill out the pith from the other end, as you did the stems for the twig bundles, and then about 12 inches from this end, drill a "side hole" of similar diameter through the bark just into the pith. Drive the stakes about 6 inches into the ground in a line across your habitat area.

- **Nesting blocks.** Bee nesting blocks can be made from blocks of water-resistant lumber at least 4 inches by 4 inches and 8 inches long. Larger lumber sizes — 4 inches by 6 inches, or even 8 inches — are better as you will be able to drill deeper holes. Avoid treated lumber, as the chemicals may affect the nests, and cedar, which has a natural pesticide (hence it being used for closets and chests to give protection from clothes moths and carpet beetles). In one side of the block, drill holes between 3/32 inch



Wooden nesting blocks and other nests for hole-nesting bees can be made in different sizes and styles.



Drill as far into the block as you can, leaving the back of the hole closed. The holes should be between 3/8" and 3/32" diameter. A range of sizes will attract a range of bees. The holes do not need to be drilled in any particular pattern.

and 3/8 inch in diameter, at approximate 3/4 inch centers. The holes need to be closed at one end, so either drill almost all the way through the block to leave a wall, or drill all the way through and then back the block with wood. When drilling, make the interior of the holes are smooth as possible. The block can be as simple or fancy as you like. A rough block of lumber will work OK, as will holes drilled in a dead tree, or you can attach the block to a backing board and fix a sloping roof, painted in attractive colors. The roof should extend beyond the front of the block to afford the nesting holes some protection from rain, hail, and snow. The block can be fixed to a stake, fence, or building, or placed in a tree, in a sunny, east or southeastward facing spot. It needs to be fixed firmly so it doesn't shake in the wind.

Bumble bee nests

Unlike solitary bees — who can be very particular about hole diameters — bumble bees are more flexible in their nesting needs. All they are looking for is a dry, warm hole of a suitable size. There are no strict requirements for this, but there are some general guidelines. The nest should be weatherproof and well insulated (the growth of the larvae can be stunted if the nest gets too cold or, in particular, too wet). Bumble bees prefer a nest with two chambers, one as the brood chamber where they will make the nest and one as an entrance. The entrance hole should be no more than 3/4 inch in diameter, marked on the outside with a contrasting color, and provided with a landing platform. Finally, the nesting chamber needs to contain insulating material, such as upholsterer's cotton or unraveled, soft string.

You can use any lumber you have available and adapt the dimensions to suit the materials you have. Do not use treated lumber, as the chemicals may affect the bees — the treatment, after all, is intended to protect the lumber from insects. The lumber used will be able to cope with the weather for several years, so there's no need to paint it. The important things are to make the joints and cracks weather tight with caulking or similar and to have a roof that will keep the rain out.

A good size for a nest is a box about 16 inches long, 8 inches wide, and 7 inches deep, with a floor that extends at the front to form a landing platform and roof that overhangs on all sides. Through each end, drill a cluster of small-diameter ventilation holes, and cover them with door screening to deter ants. Inside, the two chambers should be different sizes; the brood chamber about 71/2 inches long and the entrance chamber about 51/2 inches long, divided by a piece of 2 by 4 laid on edge across the bottom of the box. (Drill a 3/4 inch hole through this to allow the bees to pass between chambers, although they will also be able to climb over the divider.) The actual nest entrance is made by a length of 3/4 inch plastic pipe that goes through the front wall close to the floor and extends into the

entrance chamber. Highlight the entrance on the outside with paint or a marker pen to help bees find it. Finally, place a small amount of nesting fiber (upholsterer's cotton or similar) into the brood chamber before fitting the roof. The roof can be made from a single piece of plywood or two pieces of plank glued together, with a drip molding around the edges to improve rain resistance. Attach the roof to the top of the nest with a couple of screws, or simply weigh it down with a few bricks or rocks (enough to deter raccoons). You can make an inner roof of Plexiglas, so you can lift the wooden roof occasionally to look inside without disturbing the bees.

Place your nest on bricks or lumber spacers to keep it up off the damp ground, with the entrance hole between 4 inches and 10 inches off the ground. Choose a site that is undisturbed, in partial or full shade, where there is no risk of flooding, and where it is not close to a known ant colony. Put your nesting box out when you first notice bumble bees in the spring, or when the first willows and other flowers are blooming, and be patient. If it has no inhabitants by late July, put the nesting box into storage until next spring. Don't look inside your nest too often, as bees don't like disturbance.

Conclusions

Simple changes to the environment of golf courses can have great benefits for wildlife. Hopefully, these guidelines will help with the planning and management of habitat for native pollinator insects, especially bees. A flower-rich habitat for bees may also become home to hummingbirds, butterflies, beetles, and flower flies and other insects, and diverse habitats will attract other animals and birds. In addition to the wildlife benefits from the habitat, a rich insect fauna can help the golf course, as some of the insects attracted will be beneficial in themselves. Several solitary-nesting wasp species, for instance, are predators of golf course pests, such as cutworm, and will nest alongside the bees in wood nesting blocks or in the ground.

Golf courses offer wonderful opportunities for wildlife conservation. They can contain large areas of natural vegetation that are relatively undisturbed by people, providing safe refuge for wildlife as the landscapes around them come under increasing pressure. With a little care and planning these areas can support a wonderful diversity of wildlife and add beauty to the golf course landscape. Habitat areas also offer educational possibilities, not just for the golfers but also for local schools and communities who can learn about practical conservation techniques and witness first-hand the benefits of the golf course. Conservation of native bees and plants is a valuable way in which golf courses can contribute to a healthier environment, and is a simple task to integrate into the management of your golf course.

Appendix A: Bee Stings, and How to Avoid Them

One of the major concerns that people have about bees is being stung. Certainly it can be painful but except for a very small number of people who are affected by anaphylactic shock — a strong allergic reaction — being stung poses little more threat than discomfort. (Generally, people know whether they are affected by anaphylactic shock and carry an epinephrine kit.)

Memories of being stung are also a situation in which bees and wasps become confused. Wasps are closely related to bees and share similar life cycles and habitats, with some being solitary nesters and some — in particular, the yellowjackets and hornets — nesting socially. One way in which wasps and bees differ profoundly is in their diet. Wasps generally are predators and scavengers, chasing and killing insects to provision their nests or eating carrion for food. When they can, the adult yellowjackets also feed on sweet, sugary food or drink, like rotting fruit and sodas. Because of their predatory habits, wasps have effective, multiple-use stingers.

Bees, in sharp contrast, are completely vegetarian, feeding on nectar and pollen, a floral diet that only needs to be located and not subdued. Their stings are only for defense, and even then they are usually reluctant to use them. Bees are capable of stinging more than once. The honey bee is the only one that leaves its stinger in the victim (the bee will die after being eviscerated by this, another disincentive to use its sting). Some wasp species are also pollen and nectar feeders, and are as unlikely to sting as most bees.

When foraging, all bees will do their best to ignore you. Solitary nesting bees will also generally ignore you at nesting sites. Their survival strategy is to flee rather than fight. After all, it is better for a solitary bee to abandon her nest and start again elsewhere than risk dying to defend it. The social bees — honey bees and bumble bees — might sting to defend their nest if they feel threatened. Not only do they have a colony of workers and brood to defend but, in the case of honey bees, they also have a winter's supply of stored honey to protect.

Bees have highly developed senses to find and locate flowers, and flowers have many adaptations to make this easier, including colorful petals and a scent. Consequently, if you look or smell like a flower bees might be attracted to you! Bees have good color vision, seeing a range of colors from orange to violet and into the ultraviolet. They seem to be particularly attracted to flowers that are white, yellow, and, especially, blue or purple. To reduce the likelihood of bees finding you, avoid strongly scented or floral perfumes and try not to wear bold floral-pattern clothing or a lot of bright blue when on the course.

On the golf course, stay on the marked cart paths and playing areas. When a ball goes into the out-of-play habitat areas consider whether it is worth the search. By doing this you will be keeping out of areas more likely to have bees. If you do search for your ball, look carefully and avoid swinging your club at vegetation. Inadvertently swiping the entrance to a wasp or bumble bee nest on the ground could aggravate them.

Often, when a player is stung on the course it is not through malevolence on the part of the bee but simply through being caught in clothing or hair. If a bee does fly close to you, avoid swatting it. Be patient, it will fly away. If you must encourage it to go away, be gentle, slow, and deliberate in your movements, so that you minimize the chance of it getting trapped or feeling threatened.

Pheromone traps for wasps are widely available from hardware and gardening stores. These may help limit wasps when used in a

small area like a back yard or deck, but in a large space such as a golf course they have limited impact. On a golf course there are so many places beyond your control where wasps could be coming from that it is almost impossible to prevent them from flying around.

Dr. Justin Schmidt, a United States Department of Agriculture bee sting expert, has the following advice:

"Stings, though painful and frightening, are usually harmless and the intense pain will go away in five to ten minutes, or less. Residual minor pain, followed by redness, swelling, itching and minor discomfort may continue for several hours. After effects, mainly swelling, might last a day or two. If the culprit is a honey bee, the stinger will be left in the skin and should be pulled out with fingers or scraped out with a fingernail. The best treatment for the immediate pain is the application of a thick paste of ordinary salt and water to the sting area. This will give relief within a short time. Other home remedies may also have merit and should not be dangerous, but none have been shown superior to simple salt. An aspirin might be taken to help reduce potential swelling."

Managing out-of-play areas for bees is unlikely to create any greater hazard or discomfort than already exists for golfers. They are more likely to be troubled by the yellow jackets attracted to trash cans, sodas, and turkey sandwiches than by native bees benefiting from the enhanced forage and nesting habitat.

Appendix B: Useful resources

Books and Journals

Borror, Donald J., and Richard E. White. 1970. *A Field Guide to Insects. America North of Mexico*. Houghton Mifflin, Boston, MA. (This book will help you to identify insects.)

Buchmann, Stephen L., and Gary Paul Nabhan. 1996. *The Forgotten Pollinators.* Island Press, Washington, DC. (An overview of pollinators and conservation issues.)

Dodson, Ronald G. 2000. *Managing Wildlife Habitat on Golf Courses.* Ann Arbor Press, Chelsea, MI. (A useful guide to managing all types of habitat.)

Harker, Donald, Gary Libby, Kay Harker, Sherri Evans, and Marc Evans. 1999. *Landscape Restoration Handbook. 2nd Edition.* Lewis Publishers, Boca Raton, FL. (A good guide to habitat creation, with a region-by-region outline of habitats and plant communities.)

Kearns, Carol, and James Thomson. 2001. *The Natural History of Bumble Bees. A Sourcebook for Investigations.* University Press of Colorado, Boulder, CO. (A slim, very readable book, that is an excellent introduction to North American bumble bees.)

Imes, Rick. 1992. *The Practical Entomologist.* Fireside Books, New York, NY. (An introductory book that is packed full of practical entomology information: identification, collection, raising, biology, etc.)

O'Toole, Christopher, and Anthony Raw. 1999. *Bees of the World.* Blandford, London, UK. (A great introduction to bees and their biology, behavior, and lifestyle.)

Procter, Michael, Peter Yeo, and Andrew Lack. 1996. *The Natural History of Pollination.* Timber Press, Portland, OR. (An excellent book, probably the best single volume on pollination. Fairly heavy reading, but stuffed full of information on plant/pollinator relationships.)

Hortus West. The Native Plant Source Directory. PO Box 2870, Wilsonville, OR 97070. (This is a brilliant reference for plant availability and nurseries in the western states.)

Nonprofit Organizations and Companies

The Bee Works. Environmental consultancy engaged in native bee research and conservation efforts.

Stephen Buchmann, President
1870 W, Prince Road Suite 16
Tucson, AZ 85705
Tel: (520) 888-7422 Fax: (520) 888-7332
Email: steve@thebeeworks.com
Website: www.thebeeworks.com

BioQuip. Entomological equipment, books, and supplies.

17803 LaSalle Avenue
Gardena, CA 90248-3602
Tel: (310) 324-0620 Fax: (310) 324-7931
Email: bioquip@aol.com
Website: www.bioquip.com

Carolina Biological Supply Company. Science and educational equipment.

2700 York Road
Burlington, NC 27215
Tel: (800) 334-5551 Fax: (800) 222-7112
Email: check the Web site for department addresses
Website: www.carolina.com

Lady Bird Johnson Wildflower Center. A nonprofit center that is a great resource for native plant information. Can supply lists of suitable plant species for many areas.

4801 La Crosse Avenue
Austin, Texas 78739-1702
Tel: (512) 292-4200 Fax: (512) 292-4627
Website: www.wildflower.org

Native Plant Society. Divided into state societies with local chapters. The Web site of the Lady Bird Johnston center (see above) lists all the state societies.

North American Pollinator Protection Campaign. A consortium of conservation groups, government agencies, universities, and private industries from the United States, Mexico, and Canada. NAPPC participants share information and work together for the common good of pollinators across our continent.

Website: www.nappc.org

Pollinator Paradise. A company providing consultancy services and doing research on bee conservation and management for agriculture.

Karen Strickler, President
31140 Circle Drive
Parma, ID 83660
Tel: (208) 722-7808
Email: karens@w-idaho.net
Web site: www.pollinatorparadise.com

Society for Ecological Restoration. Contact their national office for local contacts, or check out their Web site.

1955 W. Grant Road #150
Tucson, AZ 85745
Tel: (520) 622-5485 Fax: (520) 622-5491
Email: info@ser.org
Website: www.ser.org

The Xerces Society. A nonprofit dedicated to preserving the diversity of life through the conservation of invertebrates. It runs education and conservation projects and produces information materials. Through its Pollinator Conservation Program it offers practical advice on habitat management for pollinator insects.

4828 SE Hawthorne Boulevard,
Portland, OR 97215
Tel: (503) 232-6639 Fax: (503) 233-6794
Website: www.xerces.org

Internet sites

Information on native bees

www.xerces.org/poll/home.htm
Information on bee conservation, biology, and life cycles.

www.loganbeelab.usu.edu/default.htm
Some good information about native bees, and links to other sites.

www.thebeeworks.com
Contains a lot of information on bees, their conservation, and education ideas.

www.pollinatorparadise.com
A site with information on native bees, especially their management.

www.earthlife.net/insects
Amazing site that has innumerable links and is stuffed full of great invertebrate information.

www.mearns.org.uk/mrssmith/bees/bees.htm
A site dedicated to bumble bees

www.ces.ncsu.edu/depts/ent/notes/Other/orn_t109/not109.html
Information on orchard mason bees.

dmoz.org/Science/Agriculture/Animals/Invertebrates/Beekeeping/Solitary_Bees/
Lots of links to Web sites on pollination and solitary bees.

www.ars.usda.gov/is/AR/archive/may00/buzz0500.htm
An article from the ARS Newsletter about recent research on alternative pollinators.

www.nappc.org
The North American Pollinator Protection Campaign.

Information on plants and bee nesting sites

www.xerces.org/poll/home.htm
Practical conservation advice and links to other Web sites.

www.cae.wisc.edu/~oliphant/bees/bombus/pollination.shtml
Some plants that bumble bees forage from and pollinate, in approximate order of flowering.

members.aol.com/beetools/bumble.htm
Building nests for bumble bees, mason bees, and soon, leaf cutter bees.

gears.tucson.ars.ag.gov/na/bgardn.html
Advice on creating a bee garden or modifying your existing garden to attract native bees.

www.nhq.nrcs.usda.gov/CCS/Backyard.html
Backyard Conservation: bringing conservation from the countryside to your backyard.

wildflower.avatartech.com/Plants_Online/index2.html
Database of native plants, seed suppliers, and native plant organizations.

www.loganbeelab.usu.edu/default.htm
Click the Bees & Gardens link for lists of plants.

www.nwf.org/backyardwildlifehabitat
The NWF Backyard Wildlife Habitat site.

Entomological and educational equipment, materials, and ideas

cvs.anu.edu.au/andy/beye/beyehome.html
Great site explaining how bees see objects, including a simulation of bee vision.

members.aol.com/yesbugs/bugclub.html
Young Entomologists' Society.

lamar.colostate.edu/~gec/4Hman/contents.htm
This site contains good education projects and activities, and information on collecting and identifying insects.

www.ent.iastate.edu/list/
A directory and search engine of insect-related Internet resources.

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Matthew Shepherd is Pollinator Program Director of the Xerces Society, based in Portland, Oregon. Matthew has extensive experience of managing both habitat management and environmental education programs.

Notes

Notes

The Xerces Society is a nonprofit organization dedicated to preserving the diversity of life through the conservation of invertebrates. The Society works to protect invertebrates and their habitats by producing information materials, presenting education activities, implementing conservation projects, and advocacy. Its main programs focus on endangered species, aquatic biomonitoring, and pollinator conservation.

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