Report to the USGA/NFWF Wildlife Links Program
October, 2000

Conservation of Native Pollinators on Golf Courses

Submitted by the Xerces Society

1. Overview

The Conservation of Native Pollinators on Golf Courses project was begun in the summer of 1997. The aim of this project was to identify how to enrich insect pollinator populations and their habitat in out-of-play areas of golf courses. The project was an outgrowth of the Forgotten Pollinators Campaign, a national conservation effort focused on native pollinators. The project was run by Xerces Society staff in partnership with scientists from the USDA Bee Biology and Systematics Laboratory in Logan, Utah.

The project had three main components:

- Surveys of insects and plants
- Enrichment of habitat areas with foraging plants and nesting sites
- Information about pollinators and their management

Project work was based in the Columbia Basin, east of the Cascade Mountains in northern Oregon and southern Washington. The major portion of the fieldwork was done on three golf courses. Close to each of these golf courses, a reference site was established that provided an area of natural vegetation in which pollinator populations could be compared with those on the courses. These sites also were used as donor sites, from which bees were transferred to enrich the golf course populations. The three golf courses and their reference sites were:

- Wildhorse Golf Course in Mission, OR (superintendent Sean Hoolehan); reference site was Bar M Ranch, Gibbon, OR.
- Veterans Memorial Golf Course in Walla Walla, WA (superintendent Joe Towner); reference site was Rooks Park/ Mill Creek, Walla Walla.
- Horn Rapids Golf Course in Richland, WA (Director of Golf Nick Rodrigues); reference site was the Arid Lands Ecology preserve, Richland.

The cooperation, hard work, and good will of all the superintendents and their staff, and of the owners and managers of the reference sites (Mr. Jerry Baker, US Army Corps of Engineers, and US Fish and Wildlife Service), contributed greatly to the project.

The work done during this project has engendered considerable interest within the golf profession, and there is a growing level of involvement by other courses. We have provided information for courses in Colorado and California, including Pebble Beach, and have been invited to help directly with pollinator conservation on a course at Fallbrook in southern California.

2. Surveys of insects and plants

Survey work was done on plants, soils, and pollinator insects.

Plant surveys were done on the courses during the first field season (summer 1997) and the soils were investigated. At the same time a literature review was undertaken to identify the likely plant communities that existed before human encroachment. Using the information gathered, a list of native plants that are attractive to pollinator insects and suitable for habitat enrichment in this ecoregion was compiled.

During the field seasons of 1997, 1998, and 1999, assessments of the pollinator insect populations were done. In the first two years, pan trapping was done on each course. A graduate student from Washington State University did the first year's sampling. Students from Whitman College, Walla Walla, collected samples the next season under the supervision of pollination ecologist Dr. Heidi Dobson. The pan traps were laid out once a week, and the resulting specimens were prepared and stored in the laboratory until the end of the season when they were transported to the USDA Bee Biology and Systematics Laboratory for identification. A total of nearly ten thousand specimens were collected. The taxonomic identification of this many specimens proved to be a serious bottleneck; the USDA has only one taxonomist available to do such work.

Trapping surveys were not conducted in 1999 because of concern over depleting bee populations. The number of specimens for most species was very low (less that ten for some genera compared with over one thousand for others), indicating that the populations of these genera were already small. USDA scientists advised us that the existing data was sufficient. They did not want to adversely impact the remaining bee populations for information that may not offer additional value.

The second method used to assess pollinator populations was monitoring of wooden bee nesting blocks. Blocks were erected in the spring or 1998 and 1999. At the end of each season (October), the blocks were collected and taken to the USDA bee laboratory in Logan for storage and investigation. They were returned to the sites in the spring. In 1999, twenty nesting blocks were erected on each site (a total of 120 nesting blocks), and were surveyed monthly basis to monitor occupancy and nesting activity. Blocks on one off-course reference site were vandalized and we lost a few during the summer. The blocks on the reference sites had much larger numbers of bees using them. In spring 2000, all of the blocks were placed on the golf courses (up to forty per course) so that each course received a boost in bee numbers.

3. Enrichment of habitat areas

3.1 Introduction of foraging plants

Based on the results of the plant surveys, our USDA pollination scientists decided that planting was not needed at Horn Rapids. The golf course was located in an area of semi-arid sagebrush desert that already contained good native plant communities. Introduction of suitable foraging plants to enrich the pollinator habitat at the other two golf courses was more difficult than initially anticipated, especially obtaining the required planting

stock. The original plan was to use the Forest Service native plant propagation project at Washington State University for supplying plants. However, Forest Service budget cuts abruptly closed all such nurseries. The head of the USDA Forest Service Cooperative Programs, Tom Landis, encouraged the Xerces Society to work with the Confederated Tribes of the Umatilla Indian Reservation native plant nursery because Wildhorse Golf Course was also a Tribal endeavor. The Tribal elders and the Wildhorse superintendent both embraced this solution on behalf of the nursery, but the nursery staff lacked the expertise and were unable to grow out the desired plants successfully. When we turned to commercial native plant nurseries for plants, we found that very few of the bee-friendly plants on the list were available, and that the available varieties were ubiquitous plant species that attracted and supported the common native bees that tend to be generalist foragers on a wide range of plants, and whose populations were already high.

The relationship between native bees and native foraging plants is important, especially for the less common, specialist bee species that forage on specific plant species. For some species, the companion plant is critical to their survival. We considered it important to use native plants from local provenance, rather than to have the local plant species grown out and shipped from another region. We explored contract collecting and growing of small quantities of plants and seed, but it is not a cost-effective option for most golf courses (although in ecological terms it may be the best).

In general, native plant nurseries carry common trees and shrubs and a range of common herbs and forbs suitable for the large-scale habitat restoration projects that provide the foundation of their economic livelihood. Thus, finding the specific flowering forbs to attract the many species of non-generalist native bees is a challenge in Washington and Oregon, and will probably be a challenge anywhere in the country. Our focus shifted to creating an economically practical plant list that could be profitably produced—both for seed collectors and nurseries. The plants attracted the widest range of bees and suited the culture of golf courses (i.e., not too tall, not unattractive, no thorns, etc.). We then found and negotiated reliable nursery sources for our golf course superintendents.

We were able to provide pot-grown native plants from the target species list during both 1998 and 1999. Planting was done at Wildhorse and Veterans Memorial, where survival of the plants depended on the involvement of the course maintenance staff. The summer of 1998 was a drought year and both golf courses lost many plants. In 1999, irrigation was the key to plant survival at Wildhorse. At Veterans Memorial in 1999, lack of water during the crucial early weeks resulted in failure of most of the planting. We then modified our planting and habitat enrichment regimes to adapt to the maintenance constraints of golf course staffs.

3.2 Creating pollinator nesting sites

Nesting sites are the second important component of bee habitat. Wooden block nests were erected on all six golf courses and reference sites. We tested the usefulness of 120 wooden blocks on wooden stakes in 1998 with the USDA advisor. In 1999, again with the USDA advisors, we again erected 120 new blocks on wooden stakes, each box with

44 holes of four different sizes. Not all the boxes survived: one of the reference sites (Rooks Park) has public access, and several boxes disappeared or were vandalized; on another (Bar M Ranch), a couple of boxes have been damaged by grazing cattle. Monthly surveying of these boxes demonstrated that they were swiftly occupied by several genera of bees and predatory wasps.

A sand pit and a sand pile were constructed by golf course personnel in the habitat area at Wildhorse, but not at either of the other sites (Horn Rapids would not benefit from either of these, as it is a sandy site). The Veterans Memorial site continues to be understaffed and under-budgeted, so many of the enhancements that could be employed there are not possible because of economic constraints.

4. Information on pollinators and their management

It became obvious early in the project that producing information in a format that was accessible to course superintendents and golfers was important. Indeed, during site visits much time was spent explaining to passing players and clubhouse staff what was happening and why the larger golf community were interested in and enthusiastic about the program. Accordingly, we reallocated resources and time, and began producing informational materials and guidelines for course superintendents and managers, and used media opportunities to spread the word.

We have prepared specific material for course superintendents and golfers (see Appendix 1 for copies):

- Guidelines for Creating Habitat for Native Pollinator Insects on Golf Courses—guidance for golf course professionals. This has been drafted and sent to Kimberly Erusha at the USGA for advice on the best method of production and distribution.
- Backyard Bee Conservation—an information sheet on simple ways people can help bees by making nesting and foraging sites

We have also promoted the project through the media. Listed below are the main radio, newspaper, and magazine stories (see Appendix 2 for copies or transcripts of the first five):

- *Living on Earth*, broadcast on National Public Radio in 1998 and repeated in 1999
- *Smithsonian* magazine, April 2000.
- *Agricultural Research* (USDA-ARS magazine), May 2000
- *High Country News*, July 2000
- *Green Section Record*, July/August 2000
- Audubon International's *Stewardship News*, August 2000
- *Golf & Environment* videomagazine, fall 2000

There is another article, currently in preparation, to be published in *Golf Course Management*. It is co-authored by Matthew Shepherd of the Xerces Society, and Dan Heagerty and William Baker of David Evans & Associates, Inc. Other articles written in various large and small newspapers across the country have referred to the project.

The Xerces Society is also producing a Pocket Guide to Pollinator Insects, to be published by Sierra Club Books, which published the Xerces Society/Smithsonian Institution book, *Butterfly Gardening: Creating Summer Magic in Your Garden*. Sierra Club Books are distributed internationally by Random House. Written for the general public, it will provide course superintendents, land managers, gardeners, and naturalists with a handy reference on pollinator insects. The Pocket Guide will emphasize the beauty and biology of pollinators, and provide sufficient information for the reader to discriminate among pollinating insects and understand the vital role of these beneficial insects. It will include an overview of the natural history of the various groups of bees and pollinator insects seen in the wild, in backyards and on golf courses, and enable identification of many of them to the family level. The contributors are eminent scientific writers, photographers, and illustrators. A scientific review panel will ensure accuracy of contents.

5. Project products

- Pollinator insect species surveys; completed during the late summer of 1997 and the spring and summer of 1998.
- Plant surveys and soil investigations, 1998
- Lists and growing characteristics of bee-friendly foraging plants.
- Native plants were introduced to habitat areas on two courses to attract native bees.
- Wooden nesting boxes were erected on the golf courses and off-course reference sites. They were monitored, taken to overwinter at the USDA laboratory in Logan, Utah, and then returned to the golf courses for emergence in spring.
- Information sheets about creating nesting boxes and bee foraging habitat have been prepared for golfers
- Guidelines for Creating Habitat for Native Pollinator Insects on Golf Courses have been drafted. These are practical methods course superintendents can use to enhance pollinator populations.
- Extensive media coverage promoting pollinators on golf courses has been achieved.

THE XERCES SOCIETY
FINANCIAL REPORT ON USGA GRANT "YEAR 3"
FOR THE PERIOD MARCH 1, 1999 - AUGUST 31, 2000
WITH SUPPLEMENTAL RECAPS OF YEARS 1 AND 2

	"YEAR 3" 3/1/99 - 8/31/00	"YEAR 2" 6/1/98 - 6/30/99	"YEAR 1" 5/1/97-5/31/98
INCOME:			
USGA	$ 45,500.00	$ 45,500.00	$ 45,500.00
EXPENSES:			
TRAVEL	3,079.57	4,824.67	6,668.55
TELEPHONE	719.32	1,457.71	1,063.94
POSTAGE	148.75	169.95	303.36
SUPPLIES	229.34	1,081.49	2,281.67
PRINTING	25.22	-	41.11
BOOKS & PERIODICALS		-	15.00
SALARIES & WAGES	33,056.50	28,675.26	17,725.12
TAXES & FRINGE	7,916.30	5,613.25	4,780.59
FILING FEES		-	15.00
EQUIPMENT		815.18	542.73
EQUIPMENT MAINTENANCE		-	200.00
CONTRACT & PROF SVCS	325.00	2,871.49	11,862.93
TOTAL EXPENSES	$ 45,500.00	$ 45,509.00	$ 45,500.00

Appendix 1
Information materials for course superintendents and golfers

- Guidelines for Creating Habitat for Native Pollinator Insects on Golf Courses
- Backyard Bee Conservation

Native Pollinators On Your Golf Course

Guidelines for creating habitat for native bees and other pollinator insects

Prepared by Matthew Shepherd, The Xerces Society,
with funding from the Wildlife Links Program
of the United States Golf Association and the National Fish & Wildlife Foundation

1. Introduction

There is a growing awareness of the importance of wildlife on golf courses. Wildlife of all sorts—wild flowers, birds and mammals, butterflies and other insects—add an extra pleasure for golfers on the course, and golf courses are being recognized as important sites for a wide range of wildlife. As urban and rural landscapes are changing under the pressure of housing or business developments and increasingly intensive agriculture, golf courses provide two conservation opportunities. First, on older courses there are often areas of original vegetation and well established animal and insect communities that can survive as the surrounding area is denuded of habitat. (This may also apply to new courses being constructed where existing habitat can be preserved within the course.) Second, new courses provide excellent opportunities for the creation of diverse habitat that can become a refuge for wildlife. Careful planning and management can optimize the environmental benefit in both situations.

Many golf courses are lovingly tended and manicured to create park-like conditions. This has been described as the "Augusta National Syndrome," a desire to replicate the image of horticultural perfection seen by millions on their television. Many golfers admire this, but such manicure needs highly intensive maintenance that is beyond the resources of most courses. Partly because of this image, there is a widely held perception among the general population that golf courses are dead landscapes treated with toxic chemicals. The reality is very different. Superintendents are actively exploring innovative ways to reduce inputs and find alternative ways 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, a clean, attractive environment, and benefits for wildlife.

The importance of good stewardship of golf courses has been recognized internationally. For example, the Royal and Ancient Golf Club of St. Andrews, Scotland, has been at the forefront of promoting better management of golf's natural heritage in Britain. Here in the United States, the U.S. Golf Association has an active program of research investigating the environmental impacts of course management. Through its Wildlife Links Program, the USGA provided funding for The Xerces Society, with help from the U.S. Department of Agriculture Bee Biology and Systematics Laboratory, to investigate the conservation of native pollinators, especially bees, on golf courses. These guidelines have been prepared as one part of that project.

2. Pollinators, the forgotten link

Pollination is a basic ecosystem function, one that is required for ecosystems to remain healthy. Pollen grains are the plant's male sex cells. Before the plant can set seed or produce fruit, it needs pollen to move from the anther to the stigma of the flowers so that female plant ovules are fertilized. Some plants do this by wind (for instance, grasses and many trees, especially conifers) and a few by water, but about two thirds of all plant species need insects or other animals to move the pollen. There are many different creatures that are attracted by the flowers to help with this. Bats, hummingbirds, moths, beetles, flies, wasps, and butterflies are all pollinators to some extent, but bees—especially native bees—are the dominant group of pollinators. Native bees fulfill a critical role in ecosystems, but too often it is a function that is taken for granted, forgotten about until it doesn't occur.

A bee may visit hundreds of flowers on a typical foraging trip, feeding on nectar and, sometimes, pollen. A female bee will also collect pollen to provision her nest. Bees are hairy insects. As they forage, pollen grains get caught in their hairs and brushed off as they visit different flowers. It is this transfer of pollen, seemingly done by accident, which maintains one of the fundamental functions that keep ecosystems healthy.

The plant communities maintained by pollinators are a fundamental resource for other wildlife that relies on them for food or shelter. Plants are the foundation of the food web, using photosynthesis to convert the sun's energy into a form that can be directly utilized by herbivores (mammals, birds, and insects) that eat these plants, and indirectly by other animals that prey on the herbivores. The loss of pollinators can result in the disruption of plant communities in wildland ecosystems, and has serious, long-term implications for many animal and insect populations. The reproduction of some communities of rare plants is already limited due to a lack of pollinators, and relies on human intervention for their survival. For example, two Hawaiian species of *Brighamia* are maintained by hand pollination done by biologists who have to rappel down sea cliffs to reach the plants.

People benefit directly from the pollination service of bees and other insects, as it is a necessary step in the production of many fruits and vegetables. In the U.S., over 100 crops need animal pollination. Without it grocery shelves would not be so well stocked: it has been estimated that one in every three mouthfuls of food we eat is the result of animal pollination. Some farmers manage colonies of solitary-nesting bees (for example, mason bees for orchards and alkali bees for alfalfa) or have hives of honey bees trucked in, but many rely on wild populations of pollinators for their crops.

Research indicates that our pollinators are in decline, and in places suffering local extinction. The primary causes of this are the destruction, modification, and fragmentation of habitat, mainly through urban growth and intensified agricultural or forestry operations. Inappropriate pesticide use have also impacted pollinators, killing insects and altering plant communities. The remaining habitat areas are often isolated patches, and have been modified by invasive plant species, pesticide use, and changes in land management.

Fortunately, populations of many native bees are quite resilient and can survive many of the 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 establishing patches of native wild flowers and nesting sites, golf courses can support thriving populations of pollinators, which in turn will help maintain wildlands, agriculture, and backyards.

3. Bee life cycles and habitat

There is a rich diversity of native bees across the USA. About 4,000 species have been identified and catalogued, ranging in length from less than one eight of an inch to over one inch. They vary in color from dark brown or black to metallic green or blue, and may have stripes of red, white, orange, or yellow. Many common names reflect the way they build nests: plasterer bees, leafcutter bees, mason bees, carder bees, digger bees, and carpenter bees. Others are named after particular habits, such as cuckoo bees that lay eggs in the nests of other bee species, or sweat bees that like to drink salty perspiration. Since most don't fit the image of a "typical" bee—yellow-striped, living in a hive, and stinging you—they are easily overlooked. Out of sight, out of mind they gently get on with the vital task of pollination.

Most, but not all native bees, live on their own. A few, like bumblebees, are social, with an overwintering queen founding a new nest in the spring that may eventually grow to include several hundred individuals. However, the vast majority of bees are solitary nesting, dedicating their brief lives to creating and provisioning a nest for their offspring. Bees will often nest in great numbers when a good nesting area is found. In these aggregations, the bees may share a nesting site but they are still solitary, working only on their own nest and not cooperating with other bees. A number of bees species are parasitic, laying their eggs in cells prepared by another species.

The adult bee usually has an active life lasting three or four weeks. The male bee will hang around good nesting areas or foraging sites 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. Just like honey bees, female native bees have amazing engineering skills, and go to extraordinary lengths to construct a secure nest. In natural conditions, many bees excavate their nests within the soft central pith of stems and twigs, or use abandoned beetle burrows in dead snags. Some species will dig a nest in bare soil, or 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. Sadly, a human desire for tidiness often results in the removal of snags and other suitable nesting places.

The nest of each bee usually has several separate cells. The number of cells may vary according to the species. Some may have only a single cell but most make more,

occasionally in excess of sixty. These are often in a line filling the hole or burrow, but some species dig complex, multi-chambered tunnels, sometimes lined with pieces of leaf or a polymer-like secretion. The cells made in lines are individually sealed and separated from the next by a cap of plant materials or soil. For example, leafcutter bees neatly trim leaf pieces from broad-leaved plants and use them as walls for 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.

The second resource bees need is a source of nectar and pollen. Adults of both sexes feed on nectar and, sometimes, pollen, but females also collect pollen to provision her nest as it contains amino acids, proteins, and vitamins that are vital nourishment for larvae. (Parasitic bee species don't collect pollen as they lay eggs in the completed nests of other bees.) Depending on the bee species, the pollen is carried between stiff hairs on the underside of the abdomen (pollen brush) or along the hind legs (pollen basket). At the nest, the female will mix pollen grains with nectar to form "bee bread," and place a loaf inside each brood cell. She then lays an egg on the loaf and seals the cell. When she has completed all the cells in her nest, the bee will seal the nest and leave. After the eggs hatch each larva will feed on the bread inside its cell until it changes into a pupa and then finally emerges.

Bees can be divided into two loose groups according to their foraging habits: generalists and specialists. Generalists are those that can 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, may rely on a single plant species or a closely related group of plants for nectar and pollen, and are more susceptible to suffer from landscape changes. (The converse is true for the plants as they may rely on a specialist pollinator. When the insect declines so does the plant.)

Most bee species need a diversity of plants to provide a supply of nectar and pollen through their life cycle. A sequence of flowering plants through the year will support a range of bee species with different flight periods. To complicate the situation, some plants offer only nectar or pollen to visiting bees. In many modern landscapes, changes in land use and land management have reduced and fragmented potential habitat, resulting in isolated habitat patches containing impoverished plant communities that cannot supply the forage required by bees. Small patches may contain a number of flowering plant species, but not enough nectar or pollen—either in total quantity or across a long enough period of time—to support pollinator populations. Habitat areas may also lack suitable nesting sites; a double threat to the bees since good foraging sites may be beyond their range from good nesting sites.

When people think of bees they tend to picture a fat bumblebee or swarms of honey bees, or even confuse them with yellow jackets, and regale you with tales of being stung. In reality these are the exceptions. It is only the social bees, those that live in a colony, that are likely to sting because they have a community to defend. Honey bees are one of the

few species that might sting, and are not even native to America. In the U.S., the vast majority of native bees have no hive to defend and passively collect nectar and pollen. When foraging away from the nest no bee is looking for conflict and will only sting as a last resort—maybe because it is being swatted or squashed, or is accidentally caught in someone's clothes. Pollinator conservation will not create a risk for golfers or staff. You are likely to have more problems from the yellow jackets attracted to trashcans than you will from native bees.

4. Helping the forgotten pollinators

There are simple steps that can be taken to improve habitat for native bees and pollinator insects on golf courses, indeed any greenspace. Managing sites for native bees should not be confused with beekeeping: no special safety equipment is required, and there is no need to handle any bees (although you can safely hold nesting blocks for native bees without any risk of being stung). The advice outlined here is focused on habitat management.

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 suitable nesting sites. Enhancing out-of-play areas by adding native plants will help local pollinator populations, but for the bees and other insects to benefit fully, nesting sites should be created.

These guidelines have been written to provide help to golf course superintendents and managers with planning and managing out-of-play and other areas on their courses. The guidelines do not attempt to give great detail about specifics of plant care. Not only are there already many excellent sources of information, golf course staff are experts are growing and caring for plants since that is what they do every day! To compound the situation, every golf course has different soils or climate, growing conditions that the staff will understand better than anybody else does.

5. Foraging habitat

5.1. Choosing the right flowers

To benefit native bees, native plants are usually the best. Your local chapter of the Native Plant Society is a worthwhile contact for advice on choosing, obtaining, and caring for local plant species. Also talk to native plant nurseries. Most are very happy to advise on all aspects of designing and planting enhancement schemes. One principle to keep in mind is that planning a plant community to suit existing site conditions is easier, less expensive, and simpler to maintain than changing the local conditions to suit a plant community. Table 1 lists some plant genera that are good for bees. Use this in conjunction with the notes below as a guide to choosing local native plants for your region.

- Use local native plants. Local native plants are usually well adapted to your growing conditions and will thrive with minimum attention. They are also well adapted to supply nectar and pollen to native bees. Horticultural varieties and hybrids, in contrast, are not necessarily suited to local conditions, and are likely to have been bred to produce showy blooms at the expense of nectar or pollen production.

- Select a diversity of plants. Chose plants with a diversity of color and shape. Color is important as bees see in a different spectrum of light from people. They do not see red colors, but are particularly sensitive to ultraviolet, and consequently are attracted to blue, violet, white, and yellow. Bee species have different tongue lengths, and thus will feed on different shaped flowers. There is a rough correlation between the depth of the flower tube and the length of the mouthparts of the bees that use them. A range of flower shapes means more bees will be supported.
- Have plants flowering all season. Select a range of species that will provide a diversity of flowers through spring, summer, and fall. This will not only support a diversity of bee species, but it will also make the habitat more attractive to golfers.
- Look at the likely habitat area. The environmental conditions of the chosen habitat area will influence 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 exposure of a prairie. The small-scale changes in soils, slope, exposure and moisture can have significant impacts on what will grow.
- What is growing already? A survey of existing wild plants can be valuable for planning, especially if the area contains original vegetation. This will guide you to which plants are local and indicate the type of plant for the growing conditions.
- 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!). 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 it.
- Avoid invasive species. Plants that are known to be highly competitive, strong growing species, 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, reducing the diversity and value of the habitat and increasing maintenance demands. They may also spread beyond the habitat patches and cause problems elsewhere on the golf course. Some cities may have code restrictions on certain noxious weed species.
- Perennials or annuals? Annuals need bare ground and gaps in the vegetation to germinate each year, are more prone to competition from weeds than perennials, and are susceptible to pre-emergent, broadleaf herbicides often used for weed control. Perennials are probably more suited to course management regimes, but can take a few years to mature and flower.
- Growth habit. 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 lost balls). Similarly, dense ground cover can make stray balls harder to find. The solution could be to restrict such plants to out-of-play areas, and introduce golfer-compatible plants elsewhere.

Table 1. Native plants for nectar and pollen.
The plant genera list below are all good sources of nectar and/or pollen. These were chosen for the semi-arid Columbia Basin. Some may not be native or grow in your region. Talk to native plant nurseries in your local area to identify species from these genera appropriate for your region.

Family	Genus	English name
Salicaceae	*Salix*	willow
Polygonaceae	*Eriogonum*	buckwheat
Berberidaceae	*Berberis*	Oregon grape
Crassulaceae	*Sedum*	stonecrop
Grossulariaceae	*Ribes*	currant, gooseberry
Rosaceae	*Geum* *Rosa*	avens wild rose
Leguminosae	*Lupinus*	lupine
Geraniaceae	*Geranium*	geranium
Linaceae	*Linum*	flax
Malvaceae	*Sphaeralcea*	globe-mallow
Cactaceae	*Opuntia*	cholla, prickly pear
Onagraceae	*Clarkia* *Oenothera*	clarkia evening-primrose
Umbelliferae	*Lomatium*	lomatium
Primulaceae	*Dodecathon*	shooting star
Polemoniaceae	*Gilia*	gilia
Hydrophyllaceae	*Phacelia*	phacelia
Labiatae	*Agastache* *Scutellaria*	giant-hyssop skullcap
Scrophulariaceae	*Penstemon* *Verbascum*	penstemon mullein
Caprifoliaceae	*Symphoricarpos*	snowberry
Compositae	*Achillea* *Aster* *Chrysothamnus* *Gaillardia* *Helianthus* *Senecio* *Solidago*	yarrow aster rabbit-brush blanket-flower sunflower groundsel goldenrod
Liliaceae	*Alium* *Brodiaea*	wild onion brodiaea

5.2. Where to plant

Although there is no increased risk of being stung due to pollinator conservation, there is still some resistance to encouraging bees close to playing areas. Fortunately, 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. Fairways, greens, and tees have specific requirements to provide a good golf game, including sward height and composition, ball visibility, and access, which mean they are unlikely to be suitable for habitat enhancement. A survey of the course and golf play will identify suitable sites.

- Playing areas. The principal playing areas (tees, greens and fairways) are obvious places that are inappropriate for active pollinator conservation. Tees and greens have special conditions that must be maintained for the course to be playable. The golfer wants to see the ball along fairways and have it travel predictably. Flowers (particularly white) will hide the ball, and some broad-leaved plants can cause uneven bounce.
- 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, and thus golfers walking or driving in to find and play their balls.
- Topography. The topography will influence the habitat through changing drainage rates, moisture levels, sun aspect, and wind exposure. For instance, south-facing slopes will be warmer, creating better conditions for sun-loving bees. Drier, warmer ground is also preferred by soil 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 already have a pollinator population. These pollinators will benefit directly and swiftly from expanding and enhancing these existing habitat patches, and changing the management regime of adjacent areas.
- Rare plants or wildlife. Be careful if you already have rare or unusual wildlife on your course. Modifying habitat of rare species could jeopardize their survival. This applies to both changing the growing conditions of a rare plant, by for example introducing plants that can out compete it for water or sunlight, or the habitat of an animal by altering the plant communities it relies upon for food and shelter.
- Size of habitat patches. There is no simple answer to how big the habitat patch should be. Foraging habits of many bee species have not been studied, and it is not known how big their home range needs to be. Some bee species have been recorded gathering nectar and pollen no more than a yard or two from their nest, others in extreme conditions, up to 15 miles. 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 better as they need sufficient foraging plants close enough to their nest. The best advice is to make habitat patches as big as possible, and create as many as you can.

- Shape of habitat patches. Whilst any habitat area can be beneficial, narrow or linear areas will be less good as disturbance to the margins (for example, from mowing adjacent grass or players moving between holes) will impact proportionately more of the habitat. Big and blocky is 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 narrower strips of natural vegetation. Joining patches together will increase their effective size by allowing wildlife to move safely between individual patches.
- Visibility of the habitat. On some courses, not all golfers will appreciate having a habitat area in a prominent location. A flower-rich prairie is a beautiful sight, but every player has his or her own idea of what a beautiful course looks like. Ensuring habitat areas are visible to players can be of great educational or interpretive value, giving an opportunity to inform players how the course is managed.
- 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 for weed control and especially watering.

5.3. What to plant?

There are two basic choices, to use seeds or transplants. Seeds have the advantage that they are cheaper than transplants so potentially you can have more plants for your money. Additionally, nurseries will probably be able to provide seed for a wider range of species than they can supply transplants. However, they can be more difficult to establish especially if being introduced into existing grassland. If a clean seed bed can be achieved (for example, when creating a new golf course) then seeding with a mix of grasses and forbs can be a successful approach. For the majority of situations, golf course superintendents are likely to be interested in adding native plants to enrich existing grassland. Transplants are usually preferred in this situation as they are better able to survive competition from existing plants. Successful establishment will require on-going maintenance (see section 5.5).

Sometimes alternative sources of planting material are available. If an area of local habitat similar to the golf course environment is being lost to development, removal of natural sod or plants may be possible. Translocation of habitat has mixed success and may not succeed. It should not be considered unless the donor habitat is going to be destroyed and this is the only way fragments can be saved. Removing plants or sod from existing habitat will damage it. Conservation management of golf courses should be in addition to existing areas, not instead of them.

5.4. Deciding how many plants

Calculating how many pounds of grass seed to use for a known area is a well established and tabulated decision making process, but deciding how many native plants to use is less easy. 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 establishment. 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 and a weakening or loss of the whole population.

- Minimum population size. The ideal target is to establish a native plant community that has enough individuals of each species so that they will be self-sustaining, each producing sufficient seed to ensure the future of the community. In simple terms, if a plant is a perennial that lives a long time then you will need fewer individual plants than if the plant is an annual. Research suggests that the minimum population needed to ensure a stable plant community ranges from as few as 50 plants for some herbaceous perennials, to more than 2500 for some annual species.
- Planting density. The choice of transplants or seeds will influence how much plant material you will need. With transplants, plan for one perennial plant every 18 inches within the habitat area (roughly 5 plants for every square yard of habitat) and annuals at a higher density of one every 12 inches (about 10 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 (this is mixed in with native grass seeds). Try to establish as many plants as you can.
- 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 100 feet), populations of plants can be spread between two or three patches. This is more suitable for perennials, which are longer lived than annuals and better able to cope with a divided population.
- Resources. Cost is inevitably a factor, not just for purchasing plant material, but also for maintenance. For example, if you want to plant 300 plants, but can't afford them in one year, stagger the planting over two or three seasons to spread the cost and work.

5.5. Plant establishment and maintenance

In some ways, the ideal approach to creating a natural area is simply to leave it alone and let Nature do her stuff. This can work well in places where there is a neighboring source of appropriate seed, and enough time. Elsewhere, land managers will be creating a natural area by using plants or seed. Growing native plants is like growing any other plants, they need to be cared for, in particular watered and protected from weed competition. Careful planting and tending during the first growing season will reap benefits later as the plants will be well established and require less maintenance in subsequent years.

- When to plant. Perennials can be planted during the fall or spring. In regions with long, cold winters, spring is better to avoid frost heave pushing plants out of the ground. Species that flower early in the season are best planted in fall so they are established in time for blooming. The natural pattern of rainfall in your region will also influence planting time. Plan to make best use of 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 planting transplants is that they can be introduced into an existing vegetation cover, which helps to suppress weeds.

- Planting. When planting pot-grown plants make sure the hole is wide enough and deep enough to accommodate the whole root mass. The different species should be distributed in a random pattern across suitable parts of the habitat area. Planting transplants on a grid pattern is not necessary, as this work should be to create a natural area.
- Irrigation. Watering during the first summer is critical. For the first six weeks, irrigate at least once a week, preferably more frequently. After that, water as needed during particularly dry or hot periods. These guidelines are not region-specific and irrigation regimes will need to be adapted to local soil, topography and climate. Mulching in the first year after planting can help to retain moisture and reduce irrigation. Irrigation in subsequent years should not be necessary—unless a drought is going to kill the plants—as this can encourage root development at the surface, making the plants more susceptible to damage by dry spells, and impede growth of the deep roots the plants need.
- Weed control. Weeds will compete for light, nutrients and water, and will stunt or prevent growth of desirable plants. Lack of weed control is one of the most common factors causing failure of plantings. Mulching the newly planted area will help to suppress growth of unwanted plants, but is unlikely to provide complete weed control. Herbicides may damage the transplants so 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 they are flowering can be good as they have just put all their resources into growing and have little left to regrow.

Seeds can be used to enrich existing areas, but are best suited to creating flower-rich grasslands on bare ground. Sometimes seeds may be the only source of plant material for particular plant species, in which case you may have to germinate them and grow plants to plant out. There are two methods to try: growing individual transplants or species-rich sod. Transplants will provide you with individual plants that can be introduced into an existing sward. The species-rich sod can be grown ready for transfer into the habitat areas, very much as a superintendent might grow a putting green nursery. Once in place, it will provide a reservoir of native plants that can spread through the surrounding area, though this can be slow process. Seed mixes are more likely to be used to establish habitat areas on new or remodeled golf courses as a component of the landscaping plan.

- Seed mix. Natural prairies often have dozens of species, but for a new area a seed mix containing no more than 15 to 20 species of native grasses and forbs will be enough. About 50 to 80 percent of the volume of the seed mix should be made up of four or five species of native grasses. A seed mix of this diversity will give a good foundation from which a richer habitat can develop through natural colonization. Choose forb species that will give a range of flowering through the seasons, and a variety of flower colors and shapes. Your native plant seed provider or Native Plant Society can advise on choice of species and amount of seeds required.
- Site preparation. The seedbed should be tilled and treated for weeds. If the site has erosion potential, conservation measures should be designed in. Soil protecting

polymers or straw mulch can be added after seeding to stabilize soil. If near a water body, erosion fences to stop silt washing into the water may be required.

- 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 may be appropriate, for larger areas a seed drill or hydro-seeding may be necessary. After seeding rake or harrow the area.
- Irrigation. As for 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 rate of establishment and growth. Once the new species-rich turf is established it should be dense enough to suppress weeds.

5.6. Habitat management

Depending on the type of vegetation community created, you may have to undertake periodic management of the habitat areas. In many areas, prairie areas left untended will develop into areas of scrub or forest, needing to be cut or burnt every few years 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 over the desired natives, leading to loss of diversity. Cutting or pulling unwanted shrubs can check their spread. During planning 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) and plants chosen that will be simple to manage, or resources identified to support management. Conservation and habitat work may be of interest to local volunteers or boy scouts (Eagle scouts often need projects for badges).

6. Bee nesting sites

6.1. Ground-nesting bees

There are several simple ways in which nesting sites can be made for bees. Many of these are mimicking natural features that bees prefer though not all will be suitable for your golf course. The adobe blocks, for example, may not last long in a rainy climate. Location of the nesting sites is important. Ground nesting bee species will avoid wet soil, so generally choose areas of dry, well-drained ground for these. In damper ground, 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 the piles.

- Bare ground. Simply clear the vegetation from a small level or gently sloping area (about 6 feet by 6 feet) and compact the soil. Where possible make these on a southeast-facing slope. A few rocks placed in the cleared area will improve it by adding basking places and help to warm the soil. Bare areas on precipitous, south-facing slopes or banks will draw different species.
- Adobe blocks. Use adobe blocks to construct a wall about 4 feet high and 6 feet long. Use wood and/or metal backing and supports to prevent toppling. Drill holes (diameter 3/32" to 3/8") into the blocks at least 4" deep.

healthier environment, and is a comparatively simple task to integrate into the management of a golf course.

The information presented here will help with the planning and maintenance of habitat areas to provide homes and food for native pollinator insects, especially bees. However, creation of habitat for bees will attract many other creatures. A flower-rich habitat may become home to hummingbirds, butterflies, beetles and other insects. These in turn will attract other animals and birds, and some of the insects will be beneficial in themselves (several wasp species are predators of golf course pests such as cutworm). Simple changes to the environment of golf courses can have great benefits for wildlife.

- Sandpit. Dig a pit about 12 feet square and 4 feet deep, and fill it with fine-grained, pale-colored sand.
- Sand pile. Create a sand pile of a similar size and materials as the sandpit.

6.2. Wood-nesting bees

For bees that prefer a wood nesting substrate it is easy to mimic the conditions of a snag. Try to place these nests so that they are sheltered from the worst of the weather with entrance holes facing towards east-southeast. Bees like warm conditions, especially in the morning so that they can become active earlier.

- Logs and snags. Get some logs or old stumps and place them in the habitat patches. Plant a few upright like dead trees to ensure some deadwood habitat stays dry. Drill holes as in the adobe blocks (3/32" to 3/8" diameter and at least 4" deep).
- Elderberry bundles. Elderberry stems are naturally used by some bee species as they have soft central pith, and can easily be used to create nesting sites. Cut elderberry stems into lengths of 8" to 12". Drill out the central pith to form a hole 3/32" to 3/8" diameter to a depth of 6" (do not drill completely through the stem), and then tie the stems in bundles of 15 to 20. Fix the bundle to a stake or tree with the stems horizontal to the ground. (Other stems with soft pith can be substituted, such as blackberry, raspberry, or sumac.)
- Elderberry stakes. Cut stakes of elderberry stems between 24" and 30" long. Drill out the pith from one end as you did the stems for the bundles, and then about 12" from the end, drill a "side hole" of similar diameter through the bark just into the pith. Drive them about 6" into the ground.
- Nesting blocks. Bee nesting blocks can be made from blocks of water-resistant lumber at least 4" by 4" and 6" long. (Redwood or cedar are good choices, but any treated wood, preferably aged, will do.) In one side of the block, drill lots of holes 3/32" to 3/8" diameter and almost all the way through the block. When drilling, make the interior of the holes are smooth as possible. Bees are not partial to roughened holes and may avoid them. Ideally, the top of the block should slope slightly towards the entrance and be capped with a plywood roof (like a bird nesting house). The roof should extend beyond the front of the block to afford the nesting holes some protection from precipitation. This block can be fixed to a stake or placed in a tree in a sunny, preferably eastward facing spot.

7. Conclusions

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. Habitat areas on golf courses also offer educational possibilities, not just for the golfers but for local schools and communities who can see the benefits of the golf course. Conservation of native bees and plants is a valuable way in which golf courses can contribute to a

Bees and wasps are often attracted to people because they smell or look good. 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 blue. On the course, stay on the marked cart tracks and playing areas. When a ball goes into the rough or out-of-play consider whether it is worth searching for or if a penalty shot is appropriate. By doing this you will be keeping out of areas more likely to have bees. If you do search for your ball, look carefully without swinging your club at vegetation. Inadvertently swiping the entrance to a wasp or bumblebee nest on the ground could aggravate them.

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 will be limited in their impact. On a golf course there so many places beyond your control where wasps could be coming from that it is almost impossible to prevent them from flying around.

Often when a player is stung on the course, it is not through malevolence on the part of the bee, 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 disorientated.

Dr. Justin Schmidt, a bee sting expert at the USDA, 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 affects, 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 yellow jackets attracted to trashcans than by native bees benefiting from the enhance foraging and nesting habitat.

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 nesting and some—in particular, the yellow jackets and hornets—social nesting. One way in which wasps and bees differ profoundly is in their diet. Wasps generally are predators and scavengers, chasing and killing insects or eating carrion for food and to provision their nests. When they can, the adult yellowjackets will also feed on sweet, sugary food or drink, like rotting fruit and sodas. Because of their predatory habits, wasps generally have effective, multiple-use stings.

Bees, in sharp contrast, are completely vegetarian, feeding on nectar and pollen, a floral diet that only requires being 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 this, another disincentive to use its sting!). Many wasps share this same life style and diet and are as unlikely to sting as most bees. When foraging, bees will ignore you. Indeed, even at nesting sites they will usually ignore you as the great majority of native bees live on their own, and 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 and thus not be able to pass on her genes to the next generation. The bees that have a colony to defend are the honey bee (a non-native species) and a few social species like bumblebees. If they feel threatened they may be aggressive in defense of the nest. The honey bee in particular will have a winter's supply of food stores to protect.

One example of how bees usually only respond aggressively when feeling threatened is a unfortunate situation when a farmer was brush hogging a rough field on his tractor. He hit a bumblebee nest and they stung him. His comment afterwards was that he had watched the same bumblebees on flowers and even touched them before and they had never stung him. It was only after their nest was "attacked" that they defended it.

Bees have highly developed senses to find and locate flowers, and flowers have many adaptations to make this easier. Bees see in a different spectrum from people. They do not see red colors, but can see in the ultraviolet. Flowers that attract bees are predominantly white, yellow, and, especially, blue. Flowers also produce scents that act as an attractant.