

WFA BRIEFING P A P E R S



This Wild Farm Alliance Briefing Paper is part of a series that explores many of the issues that define and distinguish the concept of farming with the wild. Each paper focuses on a particular issue set in the context of reconnecting food systems with ecosystems. We are striving to bridge the gap between stewardship farming and wildlands conservation. To obtain other papers in this series, or to learn more about our programs, contact the Wild Farm Alliance.

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Wild Pollinators Agriculture's Forgotten Partners

Playing a remarkable role in enabling plants to produce their fruits, wild pollinators have proven most effective on farms located close to native habitat and on diverse, pesticide-free farms. Discoveries such as these may just be the tip of the iceberg. What we have yet to learn could reveal significantly more benefits of native pollinators to farms. The cosmopolitan European honey bee (*Apis mellifera*) is the world's number-one crop pollinator, though its status is in peril. More than 4,000 other species of bee are native to North America, and many make significant contributions to agriculture. According to Losey and Vaughan, crops pollinated by wild native bees in the United States are valued at \$2 to \$3 billion per year. Without a doubt, encouraging native bees can serve as a wise insurance policy. This briefing paper highlights the often under-recognized ability of native pollinators to support agriculture, provides ways to promote wildness on the farm, and underscores the role pollinators can play as ambassadors for agricultural systems that embrace wild biodiversity.

The Web of Relations

One out of three bites of food that graces our tables does so thanks to pollinators. In fact, when comparing the broad spectrum of flavors and nutrients we consume, considerably more of both come from pollinated fruits and vegetables. The wonderful diversity of our diets owes a considerable debt to the humble pollinator.

Before the intensification of agriculture over the last 50 years, native bees handled broad crop pollination requirements. In the past century, conversion of natural areas to agriculture and urban development, along with natural habitat fragmentation, has caused more than 50 native bee pollinators to be Red-Listed, or at risk of extinction in the near- or long-term and in urgent need of protection. Information is currently limited on the majority of native pollinators, yet the potential for heavy and irreplaceable losses of biodiversity is real. Agriculture may soon lose what it does not even know it has.

Pollination has been an essential co-evolutionary aspect of agriculture for more than 3,500 years. Humans are beekeepers by nature and have been knowingly moving bees—primarily honey bees, but also bumble bees—around the planet for some time. The workhorse of all crop pollinators, however, has been the European honey bee—overall the most important species for agricultural

NATIVE PLANTS THAT SUPPORT WILD BEES

Common Name (Genus)	Flowering Period
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Trees

Willow (<i>Salix</i>)	Early spring
Sassafras	Spring
Cherry (<i>Prunus</i>)	Spring
Horsechestnut (<i>Aesculus</i>)	Spring
Maples (<i>Acer</i>)	Spring
Black locust (<i>Robinia</i>)	Late spring
Honey locust (<i>Gleditsia</i>)	Late spring
Basswood (<i>Tilia</i>)	Spring-summer
Sumac (<i>Rhus</i>)	Spring-summer
Sourwood (<i>Oxendrum</i>)	Mid-summer
Bay Laurel (<i>Umbellularia</i>)	Fall-spring

Shrubs and Forbs

Barberry (<i>Berberis</i>)	Spring
Current (<i>Ribes</i>)	Spring
Serviceberry (<i>Amelanchier</i>)	Spring
Blueberries (<i>Vaccinium</i>)	Late spring
Blackberry (<i>Rubus</i>)	Spring-summer
Elderberry (<i>Sambucus</i>)	Spring-summer
Phacelia	Spring-summer
Rhododendron	Spring-summer
Sage (<i>Salvia</i>)	Spring-summer
Spirea	Summer
Wild rose (<i>Rosa</i>)	Summer
Black-eyed Susan (<i>Rudbeckia</i>)	Late summer
Aster	Summer-Fall
Goldenrod (<i>Solidago</i>)	Summer-Fall
Sunflower (<i>Helianthus</i>)	Summer-Fall

areas around the world. The crops produced as a result of honey bee pollination are currently valued at about \$17 billion dollars in the United States alone, but it is getting risky to rely solely on these European natives. The cost of hive rentals for almond pollination has tripled in the last few years. Small farms in particular have found it more difficult to find hives, as the number of managed honey bee colonies have plummeted 50% in the United States since the 1950s, and as large beekeeping operations find it less cost-effective to drop hives at small farms. In addition, honey bees are more subject to mortality in the early spring when orchardists most need them. In some years, winter die-offs are up to 50% of all colonies. Bee keepers replenish the number of colonies later in the spring by splitting them and adding a new queen.

Without an alternative to the current practice of relying on European honey bees for pollination while disregarding native pollinators' needs, crop yields may decrease, and plants and wildlife dependent on pollinators could be disrupted. Many experts predict a new kind of silent spring—a tragedy of silent fields and orchards lacking the buzz of bees and others—that would reduce the foods we and those of the natural world eat. Nature revolves around pollination. Native pollinators have evolved by mutually benefiting from and lending their services to flowers. Take away part of their year's food source or nesting habitats, or make the distances they must fly for nourishment and cover untenable, and their numbers will eventually collapse. Because most pollinators nest in the ground, in cavities of decaying wood, or in native vegetation, intensive row-crop farming and overgrazing disrupt their activity. Pollinators do not exist in isolation; they are part of a web of relations that, with optimum management, can be conserved and restored.

Honey Bee Declines and Wilder Options

For the past few winters, dark clouds have swirled over California's hundreds of thousands of acres of almond orchards. These clouds are not the swarms of honey bees needed to pollinate the crop, however, but the lack of them. Increasingly, almond growers and beekeepers wonder where the two hives of honey bees per acre needed to shuttle pollen between almond blossoms to set the crop will come from. As almond prices hit record highs, honey bee numbers are decreasing. In fact, they have declined so significantly and the need is so great for the almond bloom, that in 2005 the 80-year-old Honey Bee Act was altered to allow imports of bee colonies from outside North America. An ill wind also blows on non-almond crops as expenses for honey bee hives go up. The so-called vampire mite (*Varroa destructor*) is largely responsible for this free fall and continues to pose a threat as it develops resistance to chemicals used to thwart it. But other factors contribute to the uncertainty, such as the encroachment of Africanized honey bees from the southeast—a region known for selling and leasing hives to the rest of the country—and the increase of an antibiotic-resistant pathogen that attacks honey bee larvae.

In the long run, if there is a silver lining in this decline of honey bees, it may be that farmers are compelled to look closer at other options—such as the native pollinators that live in and around healthy farmlands and capably transfer pollen among blossoms and flowers for free. Agriculture, with its need for pollination and its large footprint on the landscape, has an urgent reason and unique ability to help provide for native pollinators and reap their services, which will ensure that many exist into the future. When agriculture meets native pollinator food and nesting requirements, many other plants and animals also benefit. The farm, managed as part of the larger ecosystem, can support strong bee populations and may be connected to and re-colonized by native pollinators from adjacent wilder areas. While honey bees have served us well, multiple reasons exist for encouraging native bees and other pollinators on the farm.

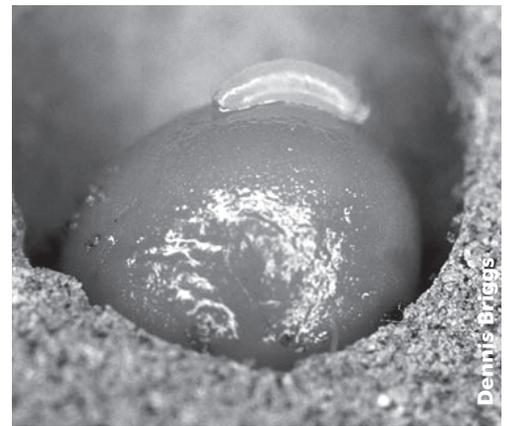
Flowers: Foods for the Gods—and for Pollinators

For 100 million years, flowers have lured pollinators with their enticing rewards. Some pollinators, like the squash bee, rely completely on one genus of flowers for their larval and reproductive success, which can be a good thing for crop production, but not so good if a bee relies on a rare plant instead. Others, like the important generalist bumble bee, collect pollen from an array of unrelated plants with overlapping blooming periods that together provide forage for all season. Even flowering weeds offer needed sustenance that can translate into better crop yields, as researchers who compare canola farming systems that do and don't use herbicides have noted. Abundant forage composed of a diversity of sizes and colors of flowers is important for pollinators, especially in the spring when insects emerge from their winter repose, and before and after the blooming season of a pollinator-dependent crop.

What You Can Do to Increase Diversity and the Abundance of Floral Resources

(listed in order of least to most complex changes to farm practices)

1. Tolerate weeds that do not displace native plants in natural areas and do not economically damage the crop for an increased set of free floral resources.
2. Grow mixed crops that provide a diversity of flowers.
3. Plant cover crops such as clover and alfalfa, and allow them to flower before turning them into the soil.
4. Seed strips of sweet alyssum, “good bug,” or wildflower mixes.
5. Install hedgerows and clusters of sequentially flowering native trees, shrubs and forbs in unused areas that are prone to invasive weeds, for example, under telephone poles, in odd shaped pieces of the parcel, and along fence lines.
6. Conserve and restore natural areas of the farm, especially those that are subject to flooding, erosion, or drainage problems, or are rocky, such as along riparian corridors and steep hillsides or in undulating grasslands.



Dennis Briggs

The young of both social and solitary bees eat protein-rich pollen balls moistened with nectar.



Davis Farm

“In the interim of [a] study [of pollinators] I became enlightened to know that honey bees were not doing all of the work in the pollination process of the crops here on the farm. Sometimes in the early morning or late evening I would notice it was always the bumble bees first and last on the job, even on the rainy days that kept honey bees home.”
—Pennsylvania Farmer Barry Davis

Native Bees and Their Nests

Bees are categorized in various ways based on their social skills, floral preferences, and nesting requirements. Honey bees are the quintessential social bee with large colonies populated by a queen, workers, and drones. Bumble bees and a handful of sweat bees are also social, requiring the assistance of colony members in order to survive. Social bees are the exception, however; most bees are solitary, such as the leafcutter, sunflower, and squash bees (to name just a few), with each female providing for her young without the help of others.

Often unnoticed, the majority of bees nest in the ground. Some build in open, well-drained sandy soils or silty loams; others seek areas of bare soil within lawns, abandoned rodent burrows, or vertical banks. Depending on the bee, the nesting area can exist for as little as a few months or as long as decades.

About 30% of North American bees nest in cavities or tunnels in wood or other materials. Carpenter bees, true to their name, excavate holes in soft, dry dead wood. Most others use tunnels already drilled by wood-boring beetles in tree snags or dead twigs. Artificial woodblocks drilled to the specific diameter requirement of tunnel nesters can provide habitat in the absence of natural features. Some orchardists purchase mason bees (*Osmia*) in wooden blocks to augment local bee populations. Depending on the species, the native female bee may have to collect mud, pebbles, or foliage to form the cell walls and end plugs that protect her nursery from pests and weather. The nest materials may have to come from long distances if not readily available. Optimizing the availability of ground- and tunnel-nesting sites and ensuring the presence of nesting materials can add to a farm's overall pollinator productivity.

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*Each nest entrance hole (above) is reigned over by a single female *Andrena* (digger) bee. Where soil conditions are right, these bees may nest together by the thousands.*

Butler Farm



Making room for habitat—that's what Lew Butler is doing on his farm. He and partners are benching back levies and installing a broad mix of native plants to benefit water quality, aquatic organisms, and crop-pollinating bees.

From a distance, the Butler Farm looks like any other large field made ready for the next rotation of tomatoes or sunflowers. But drainage ditches and Cottonwood Slough along the field edges are being terraced and tailwater ponds molded out of the bare ground thanks to Audubon California's Landowner Stewardship Program, the Natural Resources Conservation Service, and neighboring farmers. Twenty-five species of trees, shrubs, and forbs are being planted to create 1.5 miles of linear habitat to hold on to the soil, shade the streams, and provide abundant pollen and nectar for crop-pollinating bees. Interspersed throughout the habitat will be blocks of wood riddled with narrow holes, and areas of bare soil in which a variety of native bee species can nest. Over the next three years, as plants become established and mature and nest sites are colonized, scientists from Audubon, the Xerces Society and the University of California at Berkeley will monitor the changes to local populations of native bees and calculate just what it is worth to growers of insect-pollinated crops to have this habitat on their farms. This is part of a larger effort led by Audubon for watershed restoration compatible with farm systems. ◇

Native Bee Pollinated Crops and Requirements*

Crop	Native Bee ** (common name)	Native Bee (Latin name)	Nest *** Requirements	Percent Benefit
Alfalfa	Alkali bee	<i>Nomia</i> spp.	GN	≥90
Almond	Mason bee	<i>Osmia</i> spp.	TN; M	40<90
	Bumble bee	<i>Bombus</i> spp.	CN; GN	
Apple & Pear	Mason bee	<i>Osmia</i> spp.	TN; M	40<90
	Digger bee	<i>Anthophora, Andrena</i> spp.	GN	
	Bumble bee	<i>Bombus</i> spp.	CN; GN	
Avocado	Opportunistic insects	(wild bees, flies and wasps)		40<90
Black/Raspberry	Bumble bee	<i>Bombus</i> spp.	CN; GN	40<90
	Mason bee	<i>Osmia</i> spp.	TN; M; L	
Blueberry	Bumble bee	<i>Bombus</i> spp.	CN; GN	40<90
	Digger bee	<i>Anthophora, Colletes, Hapropoda</i> spp.	GN	
	Mason bee	<i>Osmia</i> spp.	TN; M; L	
Cotton	Bumble bee	<i>Bombus</i> spp.	CN; GN	10<40
	Digger bee	<i>Andrena, Colletes, Melissodes</i> spp.	GN	
	Lg. Carpenter bee	<i>Xylocopa</i> spp.	TN	
Cranberry	Bumble bee	<i>Bombus</i> spp.	CN; GN	40<90
	Leafcutter bee	<i>Megachile</i> spp.	TN; L	
Cucumber	Bumble bee	<i>Bombus</i> spp.	CN; GN	40<90
	Digger bee	<i>Melissodes</i> spp.	GN	
Eggplant	Bumble bee	<i>Bombus</i> spp.	CN; GN	10<40
Kiwi	Bumble bee	<i>Bombus</i> spp.	CN; GN	≥90
	Melon & Squash	<i>Bombus</i> spp.	CN; GN	≥90
	Squash bee	<i>Peponapis, Xenoglossa</i> spp.	GN	
	Sweat bee	<i>Halictus</i> spp.	GN	
Soybean	Digger bee	<i>Melissodes</i> spp.	GN	
	Bumble bee	<i>Bombus</i> spp.	CN; GN	10<40
	Leafcutter bee	<i>Megachile</i> spp.	TN; L	
Strawberry	Bumble bee	<i>Bombus</i> spp.	CN; GN	10<40
	Mason bee	<i>Osmia</i> spp.	TN; M; L	
	Sweat bee	<i>Halictus</i> spp.	GN	
Stone Fruit	Mason bee	<i>Osmia</i> spp.	TN; M	40<90
	Bumble bee	<i>Bombus</i> spp.	CN; GN	
Sunflower	Bumble bee	<i>Bombus</i> spp.	CN; GN	10<40
	Digger bee	<i>Melissodes</i> spp.	GN	
	Sunflower bee	<i>Diadasia, Svastra</i> spp.	GN	
	Sweat bee	<i>Halictus</i> spp.	GN	
Tomato	Bumble bee	<i>Bombus</i> spp.	CN; GN	<10
	Digger bee	<i>Anthophora</i> spp.	GN	

*For more information on these and other pollinated crops, see Klein et al. and Xerces Society.

**Since knowledge of native bees is limited, use this list as a guide to which bees are possible pollinators; other bees whose role is yet unknown are undoubtedly important.

***GN—ground nest; TN—tunnel nest; CN—cavity nest; M—mud; L—pieces of leaves.



Scott Bauer



Peter Wirz



Clemson University



Photos from top: mason bee, blueberry flowers, digger bee, cherry blossoms, bumble bee, squash flower

Full Belly Farm



Full Belly Farm nestles amid undeveloped hills, an important source of bees that visit crops and colonize the farm. Through hedgerows (top), bolting crops (bottom), and other habitat features on the farm, their operation takes full advantage of this proximity and has created an environment that both provides a conduit for pollinators to make their way into the fields, and supports them on the farm.

Just outside of California's Central Valley, tucked between hills of chaparral and oak savannah, sits Full Belly Farm. The 250-acre operation supports four families, multiple interns and farm hands, and an abundance of native pollinators. By fine-tuning its operation over the years, Full Belly Farm has produced a diverse, vibrant, successful operation that hums with pollinators, as well as other wildlife and beneficial insects. Cover crops, hedgerows, untended corners, and a diverse, organic cropping system all benefit local crop pollinators. You can find cover crops of clover beneath orchard trees, buckwheat on fallow fields in the summer, and vetch in the winter. All of these plants provide year-round and abundant forage for crop-pollinating bees. Full Belly has designed hedgerows with insects at heart. A diversity of shrubs and forbs present a buffet of flowers throughout the growing season, providing a bridge for the bees to move from one crop to the next, both in space and time. And the crops themselves also provide a steady stream of pollen and nectar. Early blooming peaches, pears, and almonds in spring make way for squash, melons, tomatoes, and peppers in the summer, not to mention the beautiful and forage-rich cutflower gardens. In addition, Full Belly allows many of its crops that don't require pollinators—such as broccoli, asparagus, and carrots—to bolt, thus adding more pollen and nectar to the mix when they stop being productive.

The result of these practices and the close proximity to abundant natural habitat, is a farm that does not require a single honey bee hive. In the words of farm-partner Paul Muller, "It's a farm that grows all of its own bees."

For information on Full Belly Farm, go to: www.fullbellyfarm.com ◇

Jefferson Farm Oak Savanna Restoration



"Because we've lost plant diversity, we also are losing bird and pollinator species," said Lynda Boyer, who coordinates restoration of oak and prairie habitats on Jefferson Farm.

Over 99% of the prairies and oak savanna in Oregon's Willamette Valley have disappeared. An inspirational project at Jefferson Farm just south of Salem, Oregon, is restoring 135 acres of this critical habitat. The farm, owned by Mark and Jolly Krautmann, will benefit both at-risk bird and plant species; but insects, especially pollinators, are also recognized as an integral component of the habitat. A key objective of this project is to establish large, genetically diverse populations of native plants, including threatened and endangered species. Most of the site had been intensively grazed or was being lost under scrub and dense oak woodland, although pockets of original grassland flora survived. Site preparation includes a combination of techniques used to control invasive and non-native plants. More than 45 species of endemic forbs and 5 species of endemic grasses will be re-established on over 100 acres of restored grassland by no-till seeding, hydroseeding, hand broadcasting and planting of plugs. In addition to the retained oaks, snags are being created and bare ground left for bee nest sites. ◇

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What You Can Do to Promote Bee Nesting Success

(listed in order of least to most complex changes to farm practices)

1. Leave snags and dead wood in trees and shrubs.
2. Irrigate conservatively to minimize the flooding of ground-nesting bees.
3. Till shallow or implement organic or low herbicide no-till practices.
4. Create patches of bare ground and provide piles of sandy loam.
5. Drill holes in dead wood and supply drilled blocks of wood.
6. Provide mud, leaves, and pebbles for nest building.

Butterflies, Birds and Other Pollinators

On a global scale, butterflies, moths, flies, beetles, and other small invertebrate species are part of a hundred-thousand-strong pollinator workforce. While providing habitat for native bees, adding a few plants to support these other pollinators is easy. Butterflies require larval host plants and species with multiple florets that produce abundant nectar. Larger pollinators—such as birds, bats, and reptiles—comprise yet another thousand species that serve an integral function. Planting red, tubular, nectar-rich flowers will provide required sustenance for hummingbirds. Supporting the full range of buzzing, gliding, and humming pollinators ensures a durable and resilient natural world.

Non-toxic, Diverse Environments

Pollinators thrive on organic farms because such farms tend to have a larger diversity of flowering plants and safe, toxic-free zones. Unfortunately, native pollinators are vulnerable to most insecticides commonly used on conventional farms. In general, the fewer pesticides used the better. Bees die both outright from insecticide exposure, and over time from repeated sub-lethal doses that build up in the nest. If insecticides must be used, larger particles (granules and coarse sprays) are better because micro-encapsulated pesticides mimic pollen; never apply pesticides to flowering plants. Spraying at night is better since female bees are usually protected in their nests at that time.

Native bees evolved in landscapes that naturally provide an array of resources. The closer farms are to native habitat resources, the more they can receive benefits from wild bees. Recent studies show that certain crops in California's Central Valley have all their pollination requirements met when 30% of the land within $\frac{3}{4}$ of a mile of a field is natural habitat. Even farms with much less natural habitat still reap important pollination services from native bees.

By reconsidering the “clean” farm strategy—a modern concept that creates a sterile, factory-like farming environment—unsightly “weeds,” shaggy shrubs, and dead trees become a beautiful smorgasbord of floral food sources and highly sought-after nesting havens for native pollinators. Creating habitat in and around crops, conserving natural areas on the farm, and working with community members to protect and restore areas of high conservation value in the surrounding region will establish a complex functioning ecosystem. Embedding agriculture in systems that mimic wild Nature will offer long-term security. ◇



Plants in the rose family support a variety of butterflies and bees.



An array of floral resources and nesting havens can support native pollinators in the wilder areas of the farm. The variety, abundance, and composition of pollinator communities on farms and the effectiveness of their pollination services are related to the availability of nearby native habitat.



The nectar within the spurs of columbine flowers is beyond the reach of most visitors but is easily accessed by hummingbirds.

What Native Pollinators Mean to a Farm Ten Reasons to Support the Wild

Compared to Honey Bees, Native Bees:

- 1. Are on the job earlier and put in longer hours.** Female squash bees often forage before dawn and males will spend the night in the flowers, resulting in very efficient pollination and larger fruits.
- 2. Are more active in colder and wetter weather.** Mason and bumble bees fly at lower temperatures and work in the rain.
- 3. Are more efficient in distributing pollen.** It only takes 250 female mason bees to pollinate an acre of cherries versus 10,000 to 25,000 honey bees (the equivalent of 1 to 2.5 hives).
- 4. Conduct buzz pollination, allowing them to pollinate selected crops that honey bees can't access.** Bumble bees behave differently. They disassociate their wings from their flight muscles and buzz blueberry, cranberry, kiwi, tomato, and watermelon flowers, vibrating the anthers so pollen pops out.
- 5. Help produce higher yields and income depending on the crop.** Alfalfa, blueberries, cranberries, and tomatoes do better with native bees.
- 6. Create a competitive situation in which honey bee pollination is increased.** With sunflower pollination, the direct interactions between honey bees and native bees causes the honey bee foragers to move more often between rows, greatly increasing their ability to cross-pollinate the seeds.
- 7. Are not susceptible to the vampire mite.** Native bees have their own pests, but because of their diversity in the landscape, when one species is in decline, others are increasing.

In Addition, Native Pollinators:

- 8. Are free.** No rental fees are paid with wild bees, butterflies, flies, and birds.
- 9. Create a diverse presence that lends pollination stability to the farm.** Farmers do not “put all their eggs in one basket” when they can rely on native pollinators for part or all of their services.
- 10. Build biodiversity.** Farms providing floral sources and nesting sites for native pollinators increase habitat for a variety of native plants and animals, from natural enemy insects to rare ecosystems and large predators.

Genetic Engineering and Wild Pollinators



When comparing different cropping systems of canola, researchers report that the greatest number of bees and floral resources, and the best pollination occurred in organic fields. There were fewer bees and flowers and a moderate pollination deficit in conventional fields, followed by the lowest bee and flower population and the largest pollination shortfall in genetically engineered fields. Increased herbicide usage was the main factor.

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- Xerces Society for Invertebrate Conservation. Pollinator conservation program. Agriculture and garden fact sheets and booklets about native pollinators http://www.xerces.org/Pollinator_Insect_Conservation/xerces_publications.htm

Thanks to the Xerces Society for Invertebrate Conservation for their assistance with this briefing paper.

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