Woodland Fish & Wildlife

Forest Bee Pollinators

Author: **Christine Buhl**, Ph.D., Oregon Department of Forestry (ODF) Entomologist

Introduction

Often, our first thought of pollinators usually takes us to honey bees in agriculture. Honey bees play such a large role in agriculture that sometimes the many wild bees that occur in other habitats such as forests are overlooked. There are over 4,000 known species of wild bees in North America (O'Toole 1991), many of which occur in temperate forest ecosystems. While this publication focuses on bees, there are also many other important insect and non-insect animals that serve as pollinators.

Bees In Forests

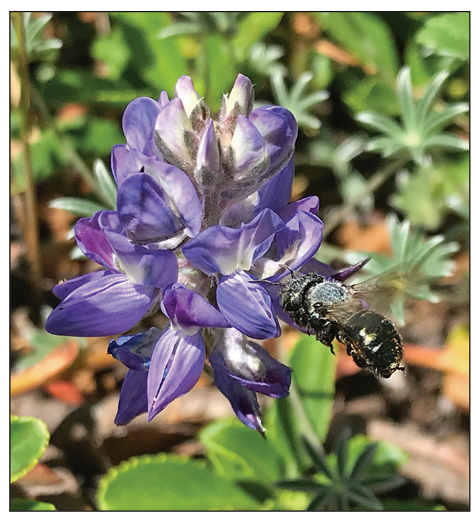
In the Pacific Northwest (PNW) alone, over 500 species of bees have been identified with an estimated 300 more awaiting formal description (Stephen et al. 1969). Despite having so many bees, we know surprisingly little about which bees occur where and in what abundance. Even less is known about the bees that utilize forest habitats (Rivers et al. 2018a). Relationships between wild bees and forest ecosystems are better studied in the tropics; but in temperate forests, where most trees are wind-pollinated, bees have been largely ignored. New research in PNW forests indicates high bee abundance and diversity, even in intensively managed forests (Rivers et al. 2018b) or forests damaged by wildfire (Galbraith et al. 2019). Forests are a great place to find certain species of native bees. These forested ecosystems offer forage and a place to make nests or hibernate. A variety of understory forbs and woody shrubs as well as some broadleaf trees provide nectar and pollen. Exposed soil and woody debris provide space for nesting, and cavities such as old rodent nests provide refuge during periods of hibernation. The types of bees found in forests vary depending on the microclimate (temperature, light, moisture, etc.), as well as the availability of preferred forage and nesting materials. As such, bee communities will vary for different levels of forest management – meaning that bee communities found in clearcuts will differ from those found in closed-canopy young forests or late successional forests.

Major disturbances such as logging and wildfire mimic early successional

*Bumble bee (*Bombus *sp.) visting waterleaf (*Hydrophyllum *sp.) in Oregon west side forest. C. Buhl, ODF*

*Sweat bee (*Augochlorella *sp.) visiting native hawkweed (*Heracium *sp.) along a forest road. C. Buhl, ODF*

*Bumble bee (*Bombus *sp.) visting inside-out flower (*Vancouveria *sp.) in Oregon west side forest. C. Buhl, ODF*

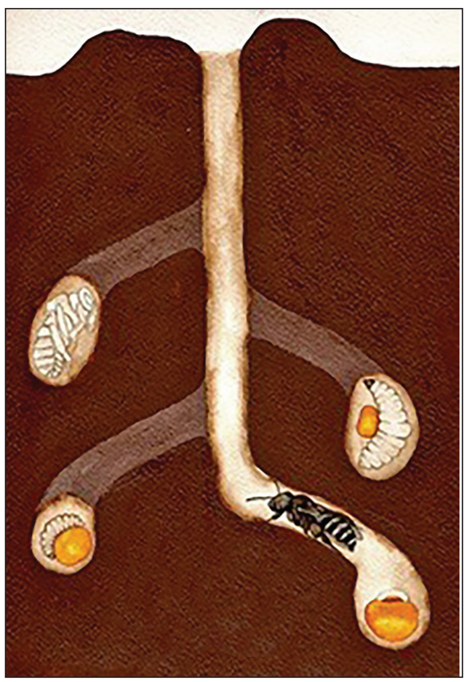


*Mason bee (*Osmia *sp.) visting lupine (*Lupinus *sp.) in recently logged Oregon east side forest. C. Buhl, ODF*

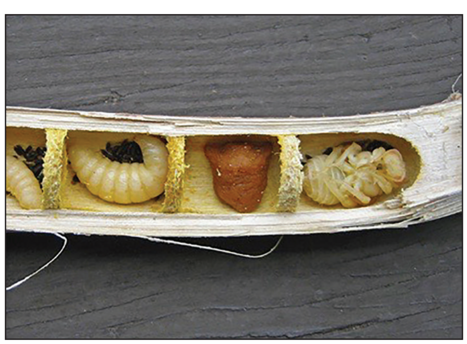
*Bee forage (*Pedicularis *sp.) in the forest. C. Buhl, ODF*

*Mining bee (*Andrenidae*) emerging from ground nest C. Buhl, ODF*

forest dynamics. Disturbance increases abundance and diversity of many bee species (Galbraith et al. 2019, Hanula et al. 2015) by: 1) exposing bare soil for ground-nesting bees and germination of forage plants, 2) increasing both light availability for forage plants and thermal environments for bee nests, and 3) leaving behind pithy (soft and easily excavated) stems and woody debris for nesting. It may be surprising to know that the majority of wild bees nest in the ground or in cavities of various materials. Exposed loose or hard-packed loam, sand, or rocky soil is utilized by a variety of bee species for nesting. Wood-nesting bees bore into wood or utilize existing cavities made by woodpeckers, wood-boring beetles, or natural decay. Other bees rely on the pithy stems of various herbaceous or woody plants for their nests. Although shallow ground nests and nests in aboveground materials may be consumed by fire, fires often move over the landscape quickly and may not have enough time to penetrate the soil of deeper nests (Cane 1991, Cane and Neff 2011). Following severe fires, bees from adjacent areas often quickly recolonize fire-damaged areas to take advantage of newly available nesting and foraging habitat.



Ground nest. Sarina Jepsen, Xerces



Stem nest. Justin Wheeler, Xerces

Bee Life History

Bee life history is highly variable among bees as a collective group. Some bees such as bumble bees are highly eusocial, while others such as mason bees tend to be more solitary. However, this is a generalization and it should be noted that variations in social behavior occur even among species within the same genera. Eusocial bees include honey bees and bumble bees and some species of sweat and carpenter bees. Much of what we know about bees is from honey bees. Honey bees are a special case because they are 'managed bees', meaning that we augment their life history by maintaining them in unnaturally large numbers within man-made hives and provide some amount of care to gain their service as crop pollinators and honey producers. In the wild, honey bees nest in much smaller numbers and in cavities such as tree abscesses. The life history of honey bees is widely known, but in North America these bees represent just one species - *Apis mellifera*; despite there being 20,000 known species of bees worldwide!

All bees develop from eggs into larvae, pupae, and then adults. But from here, life history varies widely often due to sociality. Only 10% of bee species are eusocial (UC Berkley Bee Lab). Eusocial bees live and work together to raise a colony of individuals that are divided among castes. A colony consists of a queen bee, female worker bees, and male drone bees. The queen produces unfertilized eggs, which become drones, and fertilized eggs, which develop into workers and additional queens that eventually leave to form their own colonies. Workers forage for nectar and pollen, care for the brood, and maintain and defend the colony. Drones mate with the queen and then die. Without a queen a colony would swiftly collapse. In managed honey bee populations, a single queen may live for several years, but queens of wild populations of eusocial species live for a year or less. Non-queen castes live for weeks to months. In wild populations of eusocial bees, the colony dies at the end of the season and only mated queens live to overwinter. These queens then emerge in spring to nest and start a new colony. Eusocial bees are often multivoltine meaning that they can produce multiple generations within the span of a year.

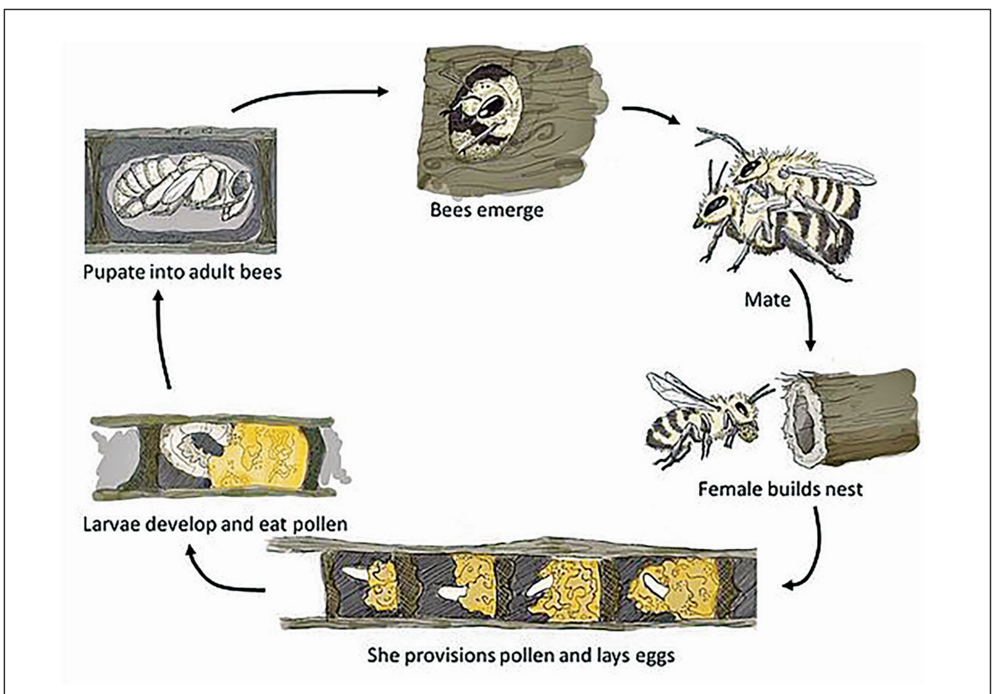
An estimated 70% of bee species are solitary and nest in the ground and another 5% of solitary bees nest in stems (UC Berkley Bee Lab). It is common for many solitary bees to occupy one location, giving the appearance of communal living. However, these solitary bees are not working together but simply aggregating, in separate nests, in a highly desirable area. Solitary bees have no colony or complex caste system. They lay individual eggs, and young develop and overwinter in their individual cells. Most solitary bees are univoltine, meaning that there is only one generation a year. They emerge as adults in the spring to mate and lay eggs that become the next generation of brood. Solitary bee eggs typically develop in less than 1 week, the hatched bees then spend 2-3 weeks as larvae. Some species overwinter in a late larval resting phase before pupating in the spring. Most solitary bee adults are active for 4-6 weeks during the blooming season. Production of brood in solitary bees typically takes place over the course of weeks versus a span of months for eusocial bees, during which fewer environmental fluctuations may occur that can impact solitary bee population numbers.

Pollination

Bees are prized for the essential ecosystem service they provide as pollinators. Some plants can self-fertilize, while others are pollinated by wind, or water. However, many plants require the aid of animals to transfer pollen. Across the globe many types of animals are capable of pollination; among these are bats and other mammals, birds, lizards, and various insects such as moths, butterflies, flies, beetles and of course bees. Pollination is also provided passively by many other animals, often when pollen sticks to their bodies as they move past plants in their search for food or shelter. Of all the flowering plants worldwide, an estimated 90% are pollinated by animals (Ollerton et al. 2011). The largest proportion of these pollination services is provided by bees. An estimated 75% of our crop plants (including feed for livestock) rely on bees for pollination (Klein et al. 2007). Pollination allows plants to reproduce, maintains genetic variability, produces products for human consumption and commerce, and contributes to environmental aesthetics.

Bee forage (Dodecatheon sp.) in the forest C. Buhl, ODF

In North America and elsewhere honey bees are known to be a pollination powerhouse although contributions by other bee species is becoming better realized (Ollerton et al. 2012). Although there are fossil records of honey bees species in North America that have long since become extinct, in the modern era, honey bees were not present in North America. Honey bees were brought from Europe by settlers to serve as generalist pollinators of many crops such as apples, melons, berries, nuts, and even cruciferous vegetables such as broccoli and cabbage. Honey bees were not brought to the west coast until the 1860s (Kellar 2014), up until which time native, wild bees provided most of the pollination services. Wild bees often outnumber honey bees, and during a period of honey bee decline (2006-2011) due to colony collapse disorder, almond



Solitary bee life cycle. Sarah Scott, USGS

Bee Declines

In 2006 reports of large honey bee colony losses, mainly in the form of missing workers, suddenly spiked in North America and was termed 'colony collapse disorder'. This prompted additional concern regarding the decline of our native, wild bees. There is no single factor to explain these losses, but the event did start a larger conversation around a complex of factors that cause sustained honey bee colony losses. These include reduction of foraging and nesting habitat, diseases and parasites, insecticide poisoning, etc. Bee population declines highlighted a need for a better understanding of pollinator health and their habitat needs, prompting a concerted effort for bee conservation beyond applications in agriculture. Since then, nationwide research efforts on bee health and habitat have expanded beyond just the honey bee/agriculture system to include bee communities in ecosystems such as forests. Research to formulate guidance for forest landowners to enhance bee habitat is still in development. In the meantime, some basic principles can be employed.

production actually increased (Olerton et al. 2012). Only honey bees are commonly managed for crop pollination, although some bumble bees and a few solitary bees are also successfully managed on a smaller scale. In eastern Oregon, farmers have successfully used native as well as established, non-native alkali bees to pollinate adjacent alfalfa crops. This solitary bee nests in the soil, so clearing ground space for these nests adjacent to alfalfa fields is all that is needed to keep these pollinators around.

Pollination is a beneficial side effect of bees visiting plants to feed on and collect nectar and pollen for their young. Bee species vary widely in the type, location, and quantity of pollen-collecting hairs and pollen-basket structures on their bodies (present under abdomens and on legs). Nectar quantity and nutrient quality can vary depending on a variety of factors such as time of day, season, plant moisture level, plant species or even cultivar. Bees are generally most attracted to flowers that are white, yellow, blue, purple and in the ultraviolet spectrum, although flower shape is more often the driving attractant. Accessibility to nectar, and therefore, flower preference, is dictated by the shape of the flower. Bees have variable tongue lengths that differ by species. Bees with longer tongues can access nectar from deeper, tube-like flowers versus those with shorter tongues that visit shallow or disk-like flowers (Roof et al. 2018). Some sneaky bees will cut holes at the base of a flower tube to steal nectar, this is called 'nectar robbing' because contact with pollen-containing structures at the opening of the flower is avoided. Some flowers are anatomically difficult to enter or have spring-like mechanisms that can prevent entry for some pollinators. For example, many plants in the pea family can be pollinated by bumble bees because these bees are generally large in size and can manipulate opening these flowers, whereas smaller bees cannot. Some bees employ 'buzz pollination', a type of sonication with forces up to 30 Gs that loosens hard-to-reach pollen grains from the sticky filaments that they are attached to (Harder and Barclay 1994). Conifers, which dominate most of our PNW forests, rely on wind for pollination and produce protein-poor pollen that is unattractive to bees. Despite this, wind-pollinated conifer and hardwood species are visited by some bee species for resin, which they use to line the cells housing their individual eggs. However, early flowering trees such as maple and willow, often provide nectar for some early-emerging bee species. Beyond

Bee tongue lengths. Encyclopedia of Life

Common bee groups in Oregon, some of which are known to occur in and along forests (note that some pollinating flies such Syrphidae hover flies superficially resemble bees):

Genus	Common name	Tongue	Nest Preference				Flight period
			Ground	Stem	Wood	Other crevice	
Agapostemon	Metallic green bee	short	X				April-Sept
Andrena	Mining, digging bee	short	X			X	March-Aug
Augochlorella	Striped metallic sweat bee	short	X			X	March-Sept
Colletes	Plasterer, Polyester	short	X				April-Sept
Halictus	Sweat	short	X				April-Sept
Hylaeus	Yellow-faced, Plasterer, Polyester	short		X	X	X	April-Sept
Lasioglossum	Sweat	short	X				March-Sept
Nomia	Alkali bee	short	X				May-Sept
Perdita		short	X				March-Oct
Anthidium	Wool carder	long	X	X	X		March-Aug
Anthophora		long	X				March-Sept
Apis mellifera	Honey bee	long				X	March-Sept
Bombus	Bumble bee	long	X			X	March-Sept
Ceratina	Small carpenter	long		X	X		March-Sept
Eucera	Longhorned	long	X			X	March-Aug
Habropoda	Dune digger	long	X				March-July
Heriades		long			X		June-Aug
Hoplitis	Leafcutter, mason, resin	long	X	X	X		April-Aug
Megachile	Leafcutter	long	X	X	X		April-Oct
Melissodes	Longhorned	long	X				June-Oct
Osmia	Mason	long	X	X	X	X	March-Aug
Xylocopa	Carpenter	long			X		April-Sept
Dufourea		some long	X			X	April-Sept

Mining/Digging bee

Mining/digging bee (Andrena) Oregon Department of Agriculture (ODA)

Sweat bee

Sweat bee (Halictus) ODA

Longhorned bee

Longhorned bee (Eucera) ODA

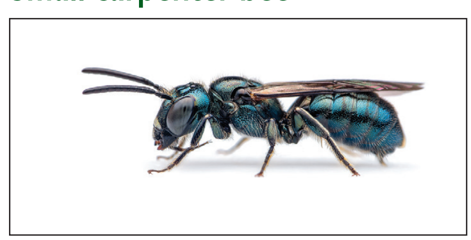
Bumble bee

Bumble bee (Bombus) ODA

Honey bee

Honey bee (Apis mellifera) ODA

Small carpenter bee



Small carpenter bee (Ceratina) ODA

Endangered And Invasive Bees

European wool carder

Currently the most threatened native bee species in the west include the western bumble bee (*Bombus occidentalis occidentalis*) and Franklin's bumble bee (*Bombus franklini*). The range of the western bumble bee historically spanned throughout all of the west coast states. Currently, the abundance of this species has declined by 84% and is isolated to the Sierra Nevada region. Franklin's bumble bee was present historically in the Siskiyous in Oregon and northern California but this species has not been found since 2006 and may very well be extinct. Another bee at risk is a species of leafcutter bee (*Ashmeadiella sculleni*). Additionally, there may be many other species not currently being monitored that may be at risk.

There are a variety of non-native bees that may become invasive as aggressors or competitors with native bees. Aggressors, such as the male European wool carder bee (*Anthidium manicatum*), physically attack other bees to guard forage space. Competitors, such as some mason bee species (*Osmia cornifrons* or *O. taurus)*, are often sold to nesting box enthusiasts although we have comparable natives such as the blue orchard/orchard mason bee (*O. lignaria*).

forests, street trees such as linden and various maples, fruit-bearing and ornamental trees such as cherry, crabapple, and apple, and larger specimen trees such as catalpa and tulip trees are reliant upon and heavily visited by pollinating bees.

Guidance

Foraging and nesting areas may not overlap everywhere on the landscape but providing a mosaic of habitat types connected by corridors, or sections of the landscape where bees can move easily between foraging and nesting habitats, can allow for higher bee species abundance and diversity at a site. Larger bees are able to travel longer distances to utilize multiple habitats, but for others, forest edges may be a richer source of bee abundance and diversity. Bumble bees have been known to travel up to 20 miles, although their typical foraging distance is less than 1 mile (Goulson 2010). Some smaller species of bees may travel less than 170 feet to forage. For these species, when searching for suitable habitat, even small separations between sources of forage become impassable 'deserts'. Bee species abundance, diversity and richness have been shown to widely fluctuate at sites. This is to be expected since features such as forage type, nesting site and material availability at a site change over time, and bee populations are not stationary and will travel to get their needs met. With the wide diversity of bee species and life histories present, dynamic assemblages of bees can be accommodated as long as we can provide a variety of habitat conditions.

Create or enhance pollinator habitat in and along forests:

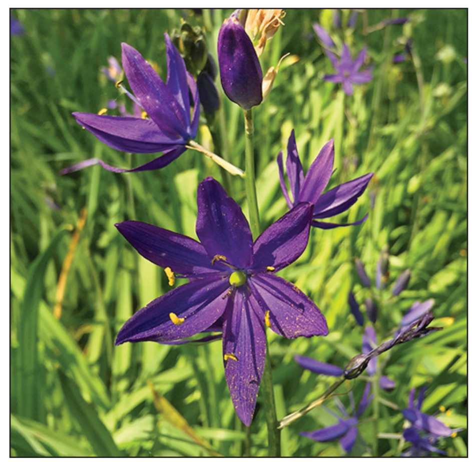
- Allow flowering plants (for forage) to grow or soil to remain bare (for nests), especially along sunlit roads and forest edges. Areas that might be inadequate for other objectives or lay fallow may serve as great bee habitat (Hanula et al. 2016). For example, old roads, skid trails and landings whose compacted soil is less suitable for tree establishment may serve as bee nesting habitat or allow root establishment for small forage plants. Pollinators in the immediate area benefit from any additional forage or nesting space although measureable increases in landscape-level bee populations occur with the addition of a quarter acre or more of pollinator habitat.
- Planting a variety of flower types will provide more forage for a variety of bees but it is best to focus on several species of plants that will do well at your site and provide the most continuous flowering window during the year. Plant species native to the area to provide the most suitable forage for local species. Observe what plant species are already doing well (and being visited by bees) at your site.
- Plant similar species or flower shapes in large patches or strips rather than in dispersed distributions. This creates a stronger signal that attracts pollinators and reduces the requirement to travel as much between flower patches to visit their preferred flower types. Bees often fixate on one type of flower to repeatedly visit during a flight. Avoid fragmentation by connecting flower patches with travel corridors that contain "like" forage to provide a trail system.

- Do not fully sanitize a stand. Leaving some pithy stems (cut stems so that pith is exposed), coarse woody debris, snags and stumps with cavities can provide valuable nesting sites. However, be aware of the potential risks of leaving an abundance of these materials onsite and contributing to wildfire fuels and forest health issues (e.g., Ips bark beetle outbreaks can develop in fresh, small-diameter pine slash and spread to standing pines).
- Leave or create patches of bare soil or sand for ground-nesting bees to colonize. Bees will not readily dig past duff layers to access soil, although they will still access exposed soil between barriers such as rocks. Various bee species will utilize all types of ground nesting habitat, from flat or piled patches of loamy soil to sandy embankments to rock walls. Nesting boxes may also be installed to serve specific species (more specifics on these structures at https://www.xerces.org/publications/fact-sheets/nests-for-native-bees).
- Provide access to water that is free from insecticide drift or leaching for a safe source of water for drinking and fortifying mud tunnels or cells. In areas where there are unsafe water sources, draw bees away by setting aside containers filled with water and materials (stones, marbles, etc.) for bees to land on while drinking.

*Lupine (*Lupinus *sp.) C. Buhl, ODF*

*Manzanita (*Arctostaphylos *sp.) C. Buhl, ODF*

*Oregon grape (*Berberis *sp.) Mary C. Legg, Bugwood.org*



Camas (Camassia sp.) C. Buhl, ODF

*Trillium (*Trillium *sp.) C. Buhl, ODF*

*Currant (*Ribes *sp.) C. Buhl, ODF*

*Willow (*Salix *sp.) C. Buhl, ODF*

- Avoid grazing or mowing when plants are actively blooming.
- Remove invasive or overly aggressive plants that reduce forage plant diversity. Although many of our native bees often visit exotic plants such as Scotch broom and Himalayan blackberry, exotic invasive species and aggressive native species reduce native plant diversity thereby reducing forage for specialist pollinator species that have co-evolved with a particular native plant.

Suggested pollinator plants for forest and forest-adjacent systems, recommended forage plant species vary by ecoregions within the PNW, Xerces society (www.xerces.org) and Natural Resource Conservation Service (www.nrcs.usda.org) maintain region-specific plant species lists *(see table on page 9)*.

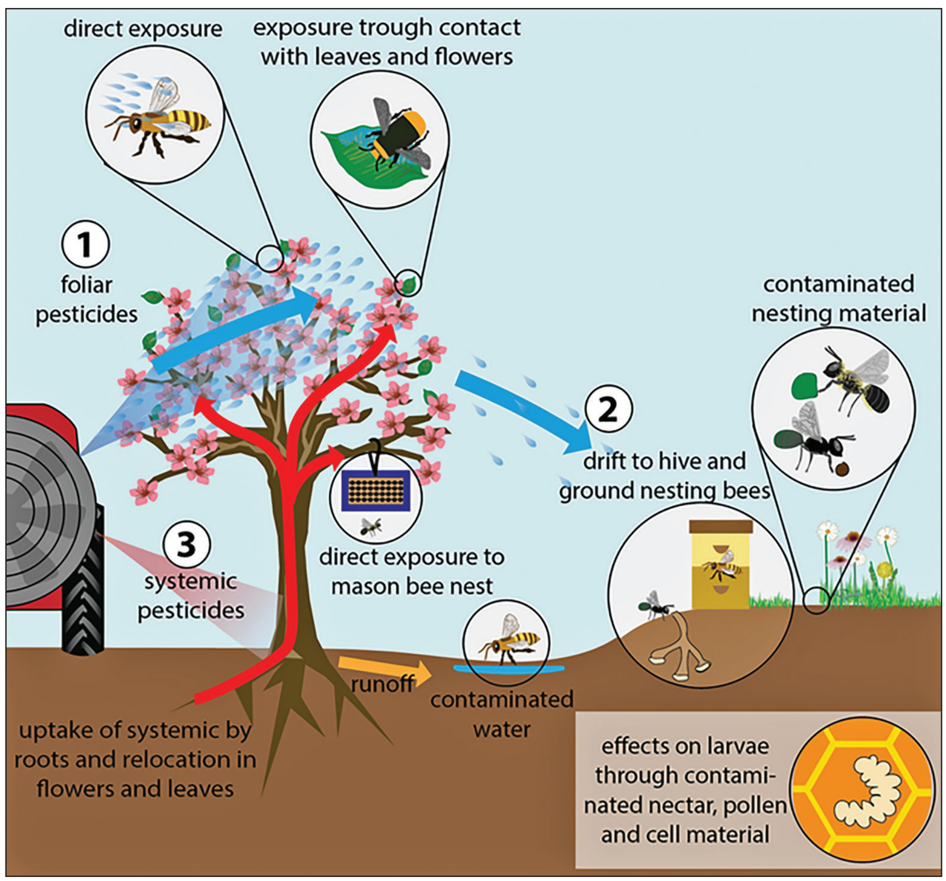
Avoid pesticide poisoning

Guidance below applies to insecticides, but be aware that other pesticides (herbicides, fungicides, etc.) may also contain harmful inert ingredients or have otherwise harmful non-target impacts on bees.

- Carefully read and follow insecticide labels for warnings on toxicity to bees and other pollinators. Oregon State University's "How to Reduce Bee Poisoning from Pesticides" app (also a printable PDF) makes it easy to search the bee toxicity warnings for active ingredients found in various pesticides.
- Utilize selective rather than broad-spectrum insecticides with lower residual times to reduce effects on non-target organisms.
- Avoid insecticide drift and leaching that may reach bees in nectar, pollen, water, soil, etc. by:
    - o Applying insecticides during days with minimal wind and no temperature inversions.
    - o Shutting off sprayers when turning equipment or when passing potential forage plants (including 'weeds' that are not the target of sprays but may be visited by bees), patches of bare soil, and water sources.
    - o Providing alternatives to ephemeral water sources such as water pooling in equipment tracks or along ditches.
- Apply insecticides after blooming period ends. Applying insecticides directly or indirectly (via drift) on flowering trees such as linden, maple or flowering shrubs and forbs can expose bees to toxins that can be deadly. Systemic insecticides to treat pests on foliage or other plant parts may also travel to nectar and pollen being collected by bees.
- Avoid applying insecticides during the time of day or season when flowers are blooming and bees are most active. Generally, bees are most active during warm (>60°F) daytime hours in spring and summer, although some species are also active just outside of these windows.
- Report any suspected bee poisoning to the National Pesticide Information Center (PARC) 503-986-6470 or via calling information at 211.

Where Do We Go From Here?

This document is meant to improve understanding of bees on our landscape and promote the idea of incorporating polli-



Routes of pollinator pesticide exposure. Iris Kormann, Oregon Bee Project

Forest reprod site seeded with pollinator forbs and leaving exposed soil and materials for nesting. C. Buhl, ODF

Burned slash pile where plant seeding and bee nesting can occur. C. Buhl, ODF

nator-friendly practices into our forest management objectives when possible. As research becomes available, we can fine-tune guidance to assist landowners in applying the most effective strategies. For example, there are many pollinator plant species lists available, but few of these are based on studies of proven, region-specific, plant species that will thrive and attract native pollinators (Garbuzov and Ratnieks 2014). Information is also lacking on patch size requirements for forage and ground nests to attract pollinators. In this early stage, landowners are encouraged to be proactive about implementing pollinator-friendly practices and trying out new strategies to find the best fit.

One of the largest knowledge gaps is baseline data of wild pollinator communities. In other words, what bee species occur where and in what abundance? For example, very little is known about habitat requirements for wood-nesting bee communities and how prolific they are in different types of forest stands. A major caveat to collecting baseline data is that bee populations are highly dynamic. This means species composition and abundance can be highly variable at a specific location from year to year without a single identifiable driver, such as phenological timing. Concerted citizen science efforts (Oregon Bee Atlas, Xerces Society surveys, etc.) are underway to address each of these research needs and are gaining momentum as the conversation on pollinator health spreads.

One of the largest knowledge gaps is baseline data of wild pollinator communities.

Bumble bee hand-netted in a managed forest. C. Buhl, ODF

Blue vane trap used for collecting bees. C. Buhl, ODF

Region-specific plant species list

Common name	Latin name	Flower depth	Bloom period
Buckthorn/Cascara	Rhamnus purshiana	short	April-May
Buttercup	*Ranunculus occidentalis, orthorhyncus, uncinatus*	short	March-July
Camas	*Camassia leichtlinii, quamash*	long	April-May
Ceanothus/Buck/Deer/Snow brush	*Ceanothus cuneatus, integerrimus, sanguineus, thyrsiflorus, velutinus*	short	April-Aug
Cinquefoil	*Potentilla glandulosa, gracilis*	short	April-July
Columbine	*Aquilegia flavescens or formosa*	long	April-June
Currant/Gooseberry	*Ribes aureum, bracteosum, divaricatum, lacustre, lobbii, sanguineum, speciosum, viscosissimum*	short	Feb-July
Dogwood	*Cornus nuttallii, sericea*	short	April-June
Elderberry	*Sambucus caerulea, racemosa*	short	March-July
False Lily of the Valley	*Maianthemum dilatatum*	short	April-May
False Solomon's Seal	*Maianthemum racemosum, stellatum*	short	March-June
Fireweed	*Chamaenerion angustifolium*	long	June-Sept
Foamflower	*Tiarella trifoliata*	short	April-July
Goldenrod	*Solidago spp. (many natives)*	short	July-Sept
Honeysuckle*	*Lonicera ciliosa, hispidula, utahensis*	long	April-July
Huckleberry	*Vaccinium deliciosum, membranaceum, ovatum, parvifolium*	long	April-Aug
Indian Plum	*Oemleria cerasiformis*	long	March-April
Lupine	*Lupinus albicaulis, latifolius, polyphyllus, rivularis*	long	May-July
Madrone	*Arbutus menziesii*	short	April-May
Manzanita	*Arctostaphylos canescens, columbiana, nevadensis, patula, viscida*	long	March-May
Maple	*Acer circinatum, macrophyllum*	short	March-June
Mariposa lily	*Calochortus*	long	May-July
Milkweed	*Asclepias cordifolia, fascicularis, speciosa, cryptoceras*	long	April-Sept
Nettle-leaf horsemint	*Agastache urticifolia*	long	May-June
Ninebark	*Physocarpus capitatus*	short	April-June
Oceanspray	*Holodiscus discolor*	short	June-Aug
Oregon Grape	*Berberis aquifolium, nervosa and Mahonia repens*	short	March-June
Oregon myrtle/California or bay laurel	*Umbellularia californica*	short	April-May
Oxalis/Woodsorrel	*Oxalis oregana, suksdorfii*	short	March-Aug
Rasp/Black/Thimble/ Salmonberry*	*Rubus leucodermis, ursinus*	short	March-July
Rhododendron/Azalea	*Rhododendron macrophyllum, occidentale*	long	April-Aug
Rose	*Rosa gymnocarpa, nutkana, pisocarpa, woodsii*	short	March-July
Salal	*Gaultheria shallon*	long	May-July
Serviceberry	*Amelanchier alnifolia*	long	April-July
Shootingstar	*Dodecatheon hendersonii*	long	Feb-May
Smooth Sumac	*Rhus glabra*	short	April-Oct
Snowberry	*Symphoricarpos albus, mollis, oreophilus*	long	April-June
Thistle*	*Cirsium brevistylum, edule, remotifolium, undulatum*	short	May-Aug
Trillium	*Trillium albidum, ovatum*	long	Feb-May
Twinberry	*Lonicera involucrata*	long	June-Aug
Violet	*Viola adunca, glabella, sempervirens*	short	Feb-July
Waterleaf	*Hydrophyllum tenuipes*	long	May-July
Western Mountain Ash	*Sorbus sitchensis*	short	June-July
Western Viburnum	*Viburnum ellipticum*	short	May-June
Wild strawberry	*Fragaria vesca, virginiana*	short	March-July
Willow	*Salix exigua, geyeriana, hookeriana, lasiandra, rigida, scouleriana, sitchensis*	short	Feb-May
Yarrow	*Achillea millefolium*	short	June-Sept
Yellow Coneflower	*Rudbeckia occidentalis*	short	June-Oct

For More Information

- **Oregon Bee Project** https://www.oregonbeeproject.org/
- **Xerces** https://xerces.org/
- **UC Berkely Bee Lab** http://www.helpabee.org/

How to reduce pesticide bee poisoning from pesticides

- https://catalog.extension.oregonstate.edu/pnw591

'Don't plant' and 'native versus non-native' lists,

- https://www.invasiveplantatlas.org/list.html?id=122
- https://weedwise.conservationdistrict.org/2017/thistle-identification.html

Agapostemon viriscens

Sources and Suggested Reading

Cane, J. H. (1991). Soils of ground-nesting bees (Hymenoptera: Apoidea): texture, moisture, cell depth and climate. Journal of the Kansas Entomological Society, 406-413.

Cane, J. H., & Neff, J. L. (2011). Predicted fates of ground-nesting bees in soil heated by wildfire: Thermal tolerances of life stages and a survey of nesting depths. Biological Conservation, 144(11), 2631-2636.

Encyclopedia of Life Observer Cards: Bees. www.education.eol.org/observer_cards/

Galbraith, S. M., Cane, J. H., Moldenke, A. R., & Rivers, J. W. (2019). Wild bee diversity increases with local fire severity in a fire-prone landscape. Ecosphere, 10(4), e02668.

Garbuzov, M., & Ratnieks, F. L. (2014). Listmania: the strengths and weaknesses of lists of garden plants to help pollinators. BioScience, 64(11), 1019-1026.

Goulson, D. (2010). Bumblebees: behaviour, ecology, and conservation. Oxford University Press on Demand.

Hanula, J. L., Horn, S., & O'Brien, J. J. (2015). Have changing forests conditions contributed to pollinator decline in the southeastern United States?. Forest Ecology and Management, 348, 142-152.

Hanula, J. L., Ulyshen, M. D., & Horn, S. (2016). Conserving pollinators in North American forests: A review. Natural areas journal, 36(4), 427-439.

Harder, L. D., & Barclay, R. M. R. (1994). The functional significance of poricidal anthers and buzz pollination: controlled pollen removal from Dodecatheon. Functional Ecology, 509-517.

Kellar, B. (2014). Honey Bees Across America. Oregon State Beekeepers Association. https://orsba.org/ Web Accessed 2019.

Klein, A. M., Vaissiere, B. E., Cane, J. H., Steffan-Dewenter, I., Cunningham, S. A., Kremen, C., & Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society of London B: Biological Sciences, 274(1608), 303-313.

Moissett, B., & Buchanan, S. (2010). Bee basics: an introduction to our native bees. USDA, Forest Service.

Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals?. Oikos, 120(3), 321-326.

Ollerton, J., Price, V., Armbruster, W. S., Memmott, J., Watts, S., Waser, N. M., ... & Tarrant, S. (2012). Overplaying the role of honey bees as pollinators: a comment on Aebi and Neumann (2011). Trends in Ecology and Evolution, 27(3), 141.

O'Toole, C., & Raw, A. (1991). Bees of the World. Blandford Press.

Rivers, J. W., Galbraith, S. M., Cane, J. H., Schultz, C. B., Ulyshen, M. D. and Kormann, U. G. (2018a). A review of research needs for pollinators in managed conifer forests. Journal of Forestry 110, 563-572.

Rivers, J. W., Mathis, C. L., Moldenke, A. R., & Betts, M. G. (2018b). Wild bee diversity is enhanced by experimental removal of timber harvest residue within intensively managed conifer forest. GCB Bioenergy, 10(10), 766-781.

Roof, S. M., DeBano, S., Rowland, M. M., & Burrows, S. (2018). Associations between blooming plants and their bee visitors in a riparian ecosystem in eastern Oregon. Northwest science, 92(2), 119-136.

Stephen, W. P., Bohart, G. E., & Torchio, P. F. (1969). The Biology and External Morphology of Bees with a Synopsis of the Genera of Northwestern America.

Wilson, J. S., & Carril, O. J. M. (2015). The bees in your backyard: a guide to North America's bees. Princeton University Press.

About the Woodland Fish and Wildlife Group

The Woodland Fish and Wildlife Group is a consortium of public agencies, universities, and private organizations which collaborates to produce educational publications about fish and wildlife species, and habitat management, for use by family forest owners in the Pacific Northwest.

Currently available publications can be viewed and downloaded, free of charge, at the organization's website:

www.woodlandfishandwildlife.com

Comments or other communications may be directed to:

Woodland Fish and Wildlife Group
c/o Executive Director
Western Forestry and Conservation Association
4033 SW Canyon Road
Portland, OR 97221
(503) 226- 4562
richard@westernforestry.org

The Woodland Fish and Wildlife Group gratefully acknowledge funding support provided by USDA Forest Service, Pacific Northwest Region, State and Private Forestry.

Project Partners

Washington State Department of Natural Resources

Oregon Department of Forestry

Cafferata Consulting

Forest Service, U.S. Department of Agriculture

Oregon Association of Conservation Districts

Oregon Forest Resources Institute

Washington Farm Forestry Association

Washington Association of Conservation Districts

Washington Department of Fish and Wildlife

U.S. Fish & Wildlife Service, Department of the Interior

Oregon Fish & Wildlife

World Forestry Center, 50th Anniversary

Oregon Small Woodlands Association

Washington State University Extension

USDA Natural Resources Conservation Service, United States Department of Agriculture

Oregon State University | OSU Extension Service

WFCA Western Forestry and Conservation Association