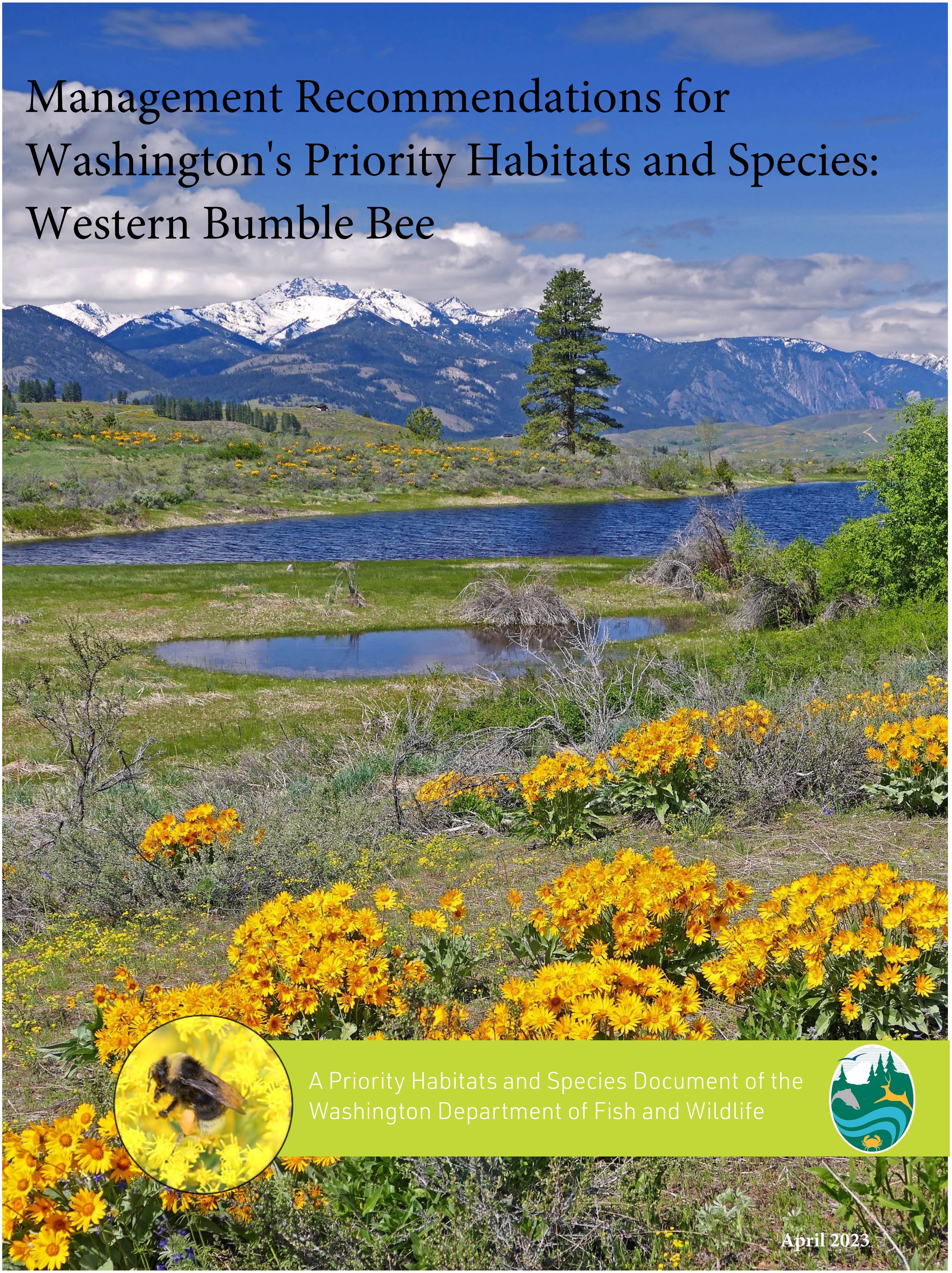
Management Recommendations for Washington's Priority Habitats and Species: Western Bumble Bee



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Cover photos courtesy of Rich Hatfield (Close up of Western Bumble Bee) and Scott Fitkin (Arrowleaf Balsamroot in bloom on the Methow Wildlife Area)

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General Range and Washington Distribution

The western bumble bee (*Bombus occidentalis*) was once broadly distributed throughout western North America, with its range extending from southern British Columbia to central California, east to Saskatchewan and the northwestern Great Plains, and south to northern Arizona and northern New Mexico (Williams et al. 2014, COSEWIC 2014, Sheffield et al. 2016, Williams 2021). The subspecies of western bumble bee, *B. occidentalis mckayi*, was recently declared a distinct species, different from *B. occidentalis* (Williams 2021). These taxa (hereafter *B. occidentalis* and *B. mckayi*) are geographically separated within the historical range, with *B. mckayi* dominant north of 55⁰ latitude and *B. occidentalis* dominant south of 55⁰ latitude (Rohde 2022).

In Washington, the western bumble bee was once found throughout much of the state, with the potential exception of low elevation portions of the Columbia Basin (Figure 1[1]). Rangewide analysis suggests that the western bumble bee has undergone a range decline of 28 to 53% between recent and historic time periods (Hatfield et al. 2018, Cameron et al. 2011a). Although suitable habitat for foraging, nesting, and overwintering is broadly distributed across the state, this species is now more restricted to high elevations east of the Cascade Crest, although some suitable habitat remains west of the Cascades and in lower elevations throughout the state (Figure 1). The western bumble bee is rarely found in the western coastal portions of Washington where it was once common, except for the area around Sequim in the northeastern Olympic Peninsula (Cameron et al. 2011a, Graves et al 2020).

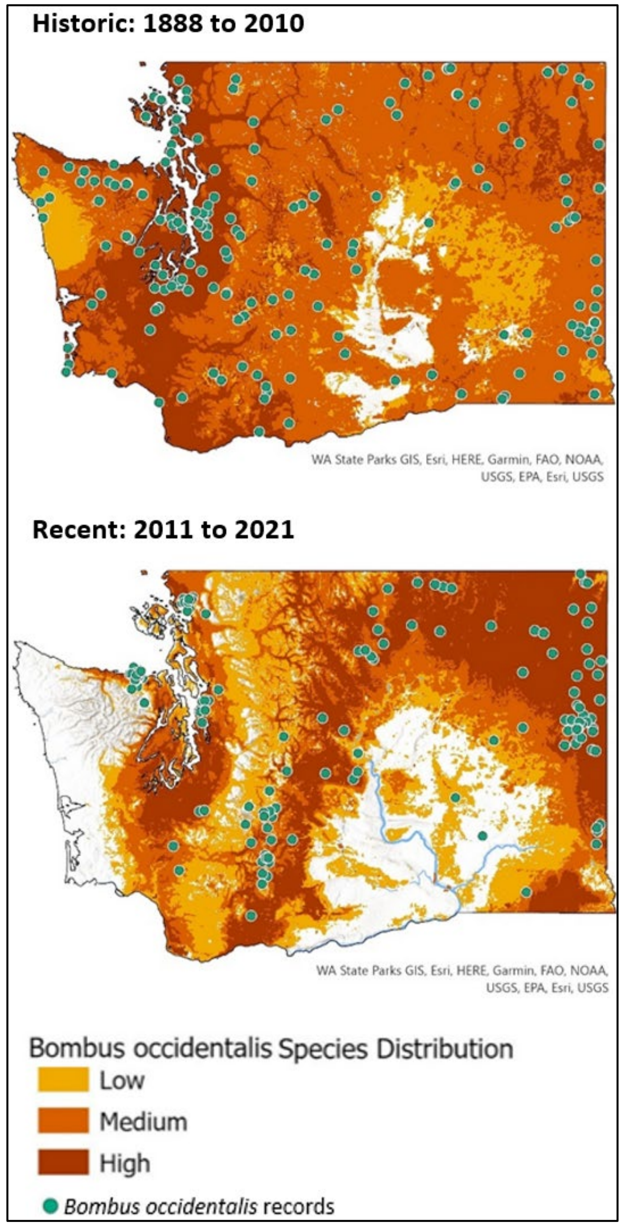

Figure 1. Modeled historic and recent western bumble bee species distribution in Washington along with points showing historic and recent records of the species.

Rationale

Bumble bees (*Bombus* spp.) occur throughout much of the world, providing important ecosystem services by pollinating wild and cultivated plants. Bumble bees are particularly important pollinators in a

1 See Appendix 1 for information about the species distribution model used to develop these maps.

variety of ecosystems and landscapes, from rural to urban, and agricultural to natural, because of a combination of attributes unique to this genus (Goulson et al. 2008). These attributes include their role as mainly generalist foragers, visiting a wide range of plants to collect resources (nectar and pollen), their capacity to survive in cold climates and fly in inclement weather, and their ability to pollinate certain groups of plants more effectively than other pollinators by “buzz” pollinating, a process that involves the vibration of flight muscles at the correct frequency to release pollen (Goulson et al. 2010).

The western bumble bee (Figure 2) was once one of the most common bumble bees in the Pacific Northwest, accounting for more than 15% of all observations (Williams et al. 2014, Rhoades et al. 2016). Unfortunately, populations of many species of bumble bees around the world, including the western bumble bee, are decreasing in range and abundance (Kerr et al. 2015, Cameron and Sadd 2020, Hatfield et al. 2021a, Graves et al. 2020). Graves et al. (2020) documented a 93% decline in the western bumble bee’s probability of occupancy across the western U.S. in the past 21 years. The relative abundance of the western bumble bee has declined by 84% when comparing records from 2002 through 2012 to pre-2002 records (Hatfield et al. 2018). Western bumble bee populations crashed in the 1990s, likely due to a combination of several factors (Graves et al. 2020). While the causes of these declines are not fully understood, likely contributing factors include habitat loss and fragmentation, exposure to pesticides and pathogens, climate change, and competition with non-native species (Graves et al. 2020).

Figure 2. Western bumble bee from northwest Oregon. Note the black face and vertex, yellow band across the front of the thorax, and white across the rear portion of the abdomen. This color pattern, particularly the white, is unique to this species and distinguishes it from other bumble bee species in the pacific northwest.

The western bumble bee became a Washington State Candidate Species in 2021 in response to recent declines. The species is also under consideration for a federal listing by the U.S. Fish and Wildlife Service under the Endangered Species Act (USFWS 2022).

Protecting the remaining suitable habitat for western bumble bee in Washington is an important strategy for maintaining the species’ genetic diversity, particularly as climate change causes more substantial impacts and conditions continue to deteriorate across portions of the species’ range.

Habitat Requirements

Most species of bumble bees are eusocial, meaning they primarily reside in colonies of related individuals that cooperate to support the colony by foraging for food, rearing offspring, and defending the nest. This cooperative lifestyle, with many individuals centered around a single nest, influences the habitat that they require for foraging, nesting, and overwintering.

For the most part, bumble bees have an annual lifecycle, which means most individuals in the colony live about one year or less (Williams et al. 2014). Reproductive females (queens in true bumble bees) are the only caste that overwinters. Generally, a mated queen starts a new colony in early spring by selecting a nest site, laying her first generation of eggs, and collecting resources (pollen and nectar) to support her future offspring (Figure 3). The queen cares for her offspring until the first brood of female workers emerge as adults. Once these first offspring have emerged, they take over the responsibility of foraging, tending to offspring, feeding and cleaning the queen, and defending the nest. In most circumstances, the queen never leaves the nest again and continues to lay eggs and oversee the growth of the nest. Only at the end of the summer does the colony produce reproductive females and males. These reproductive individuals leave the nest to mate. Following mating, the males die, and the newly mated queens search out for hibernacula, often in holes in the ground, where they undergo diapause through the winter (Williams et al. 2014).

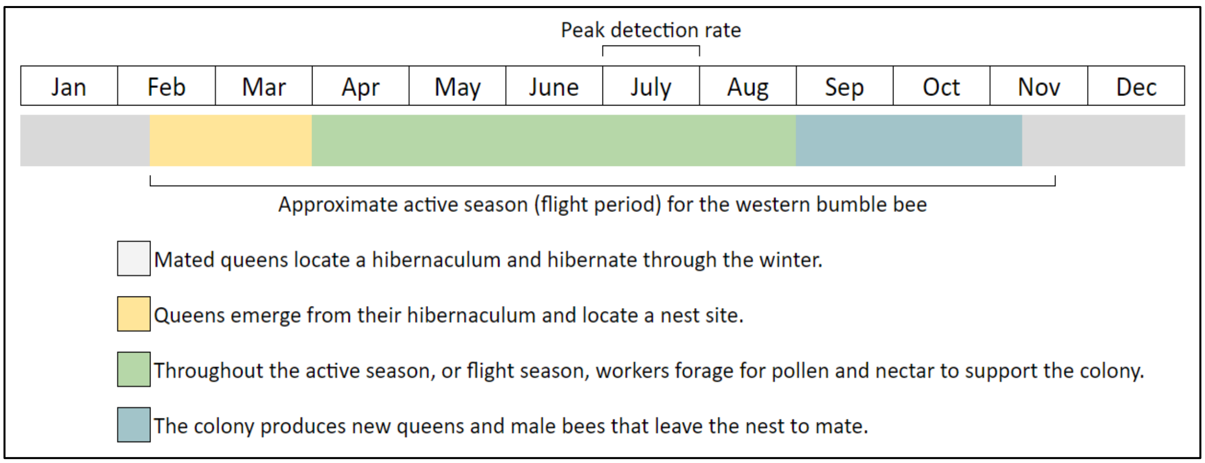

Figure 3. The general life cycle of the western bumble bee (Williams et al. 2014, Winfree et al. 2011, Cameron and Sadd 2020, Graves et al. 2020, Hatfield et al. 2021a). Exact timing of each life stage varies depending on a range of factors including latitude and elevation. Additionally, life stages will likely overlap within a given region.

Colony sizes vary among bumble bee species. Among other factors, the size of a colony is likely based on the availability of resources in its proximity. Although western bumble bee colonies are rarely observed, one study indicated that they could have up to 1,685 workers and can produce up to 360 new queens (Macfarlane et al. 1994). Although this likely exceeds the size of a typical western bumble bee colony, it is larger than the numbers that have been reported for many other species of bumble bee.

Foraging Habitat

Bumble bees require foraging habitat with a diverse assemblage of plants that can allow for continuous foraging from early spring through fall (Figure 4; Winfree et al. 2011, Cameron and Sadd 2020). The amount of pollen available to foragers throughout the flight period directly affects the number of new queens that a bumble bee colony can produce. As such, high quality foraging habitat is essential for healthy bumble bee populations (Burns 2004).

All foraging takes place during a period known as the active season, or flight period. The active season begins when queens first emerge from overwintering in the spring and ends when workers die. This may be either before or after new queens enter overwintering sites in the fall.

Western bumble bee sightings in Washington mainly occur between early April and late August (Hatfield et al. 2021a). Although timing can vary by elevation, the peak detections of western bumble bees throughout their U.S. range is around mid-July (Graves et al. 2020). Observations in California suggest that the active season for western bumble bee queens is from early February to late November, peaking in late June and late September (Thorp et al. 1983). In California, workers and males have been observed from early April to early November, with worker abundance peaking in early August and male abundance peaking in early September (Thorp et al. 1983). Due to changes in climate since Thorp's et al. (1983) original observations and given that western bumble bee is no longer found in low elevation sites in California, the timing of the life cycle for this species may likely have changed. This timing should also be interpreted with caution given geographic and climatic differences between Washington and California.

Figure 4. High quality western bumble bee habitat includes 1) a diversity of native floral resources throughout the species' active period; 2) suitable habitat for nesting; and 3) suitable habitat for overwintering.

Bumble bees, including the western bumble bee, are generalists that collect nectar and pollen from a wide range of plants (Hatfield et al. 2012). Multiple bumble bee species may occupy the same habitat, with foraging niches partitioned to some degree by tongue length (Harder 1983, Miller-Struttman et al. 2015). The length of a bumble bee's tongue governs its foraging choices, with bees preferring flowers with a similar depth to their own tongue length. The western bumble bee has a short tongue and is best suited to forage on open flowers with short corollas (Hatfield et al. 2018). Western bumble bees also engage in a behavior called 'nectar robbing' in which they chew a hole in the base of flowers with long corollas to obtain nectar without facilitating pollination (Irwin et al. 2010).

Bumble bees generally forage relatively close to their nests. This likely reduces the energetic cost of longer flights (Heinrich 2004). Different species of bumble bees vary in the distance they will travel to forage. A maximum foraging distance of over 11 km was recorded for yellow-faced bumble bees (*B. vosnesenskii*) when resources were not available near the nest (Rao and Strange 2012).

A study of western bumble bees in Washington, Oregon, and Idaho found that this species was most often associated with the following habitat types: grasslands/meadows, forests, and developed areas (Hatfield et al. 2021a). These habitat associations, particularly the association with developed areas, do not necessarily reflect a preference for these habitats over other habitats, but rather may reflect that there were more surveys conducted near where people live. Forests often provide important early season foraging habitat due to their high density of early-flowering plants (Inari et al. 2012, Wray et al. 2014, Kämper et al. 2016, Mola et al. 2021). Other habitats, including meadows and developed areas, provide important middle- and late-season foraging habitat.

Floral resources are most limited during early spring and late fall. Thus, the availability of flowers is critical during these periods of scarcity (Jepsen and Jordan 2013). Laboratory evidence suggests that a diet of more diverse sources of pollen early in the season produces more robust colonies later in the year (Watrous et al. 2019). Due to their short tongue length, western bumble bees are frequently found on plants with small flowers, including knapweeds, thistles, and meadowsweet (Hatfield et al. 2021a). Western bumble bees may be found on other types of flowers, particularly given their tendency to be nectar-robbers, chewing holes in corollas to access nectar. Hatfield et al. (2021a) found that the top ten plant genera associated with the western bumble bee in Washington State, in descending order, were: *Centaurea, Cirsium, Spirea, Lupinus, Lavandula, Solidago, Chamaenerion, Anaphalis, Hypericum*, and *Origanum*. Similarly, in an analysis largely based on records from California, Thorp et al. (1983) report that western bumble bee records are primarily associated with plants in the *Leguminosae* (*Fabaceae*), *Compositae* (*Asteraceae*), *Rhamnaceae*, and *Rosaceae* families. Note that these floral associations do not necessarily represent western bumble bees' preference for these plants over other flowering plants, but rather may represent the abundance of these flowers in the landscape. See Appendix 2, titled "*List of native plants that serve as resources for western bumble bees,*" for more information on plants used by western bumble bees.

Nesting Habitat

Queen bumble bees emerge from diapause in early spring to search for a suitable nest site. Bumble bees are generalists in their nesting patterns and can nest in a variety of landscapes and ecosystems, including agricultural and urban landscapes as well as in alpine, dune, forested, forest edge, and grassland ecosystems. A review of bumble bee nesting habitat identified grasslands, agricultural lands, and forests as the most common landscapes for bumble bee nesting (Liczner and Colla 2019).

Nesting habitat requirements for bumble bees are understudied, likely because of how challenging it is to locate nest sites. Western bumble bee nests are found mostly underground, although nests are sometimes found on ground surfaces or aboveground (Figure 4). Most western bumble bee nests are in underground cavities, including in abandoned rodent burrows on open west-southwest facing slopes, bordered by trees, although a few nests have been reported in aboveground locations (Plath 1922, Hobbs 1968, Thorp et al. 1983, Macfarlane et al. 1994). Availability of nest sites for the western bumble bee may depend on rodent abundance (Evans et al. 2008). Two western bumble bee nests were recently observed in Washington and Oregon in relatively open, flat grassland areas (R. Hatfield, pers comm.). The entrance holes of these nests were only a couple of centimeters in diameter.

Western bumble bee nest tunnels have been reported to be up to 2.1 meters (m) long, although most tunnels are likely much shorter, and nests may be lined with grass or bird feathers (Macfarlane et al. 1994). Floral resource availability within a landscape generally corresponds to the density of bumble bee nests, and therefore nesting success. This is likely due to increasing foraging efficiency as workers do not have to travel as far from the nest to find nectar and pollen and face less risk of predation or accidental death during shorter foraging excursions (Osborne et al. 2008, Knight et al. 2009, Hatfield et al. 2021b). Nest sites may co-occur for multiple colonies in habitat suitable for foraging, but nesting habitat may also be in locations that are different from foraging habitat (Lonsdorf et al. 2009). Bumble bees likely do not require flowering resources in the immediate vicinity of their nests, often foraging 100 m (330 feet) or more from the entrance of the nest (Dramstad 1996, Dramstad et al. 2003, Osborne et al. 1999). However, access to flowering resources within 100 m of a nest may improve foraging efficiency, especially during nest establishment in the spring (O'Connor et al. 2017, Liczner and Colla 2019).

Overwintering Habitat

Like nests, overwintering habitat is not well understood because it is hard to find. From what we know, the overwintering habitat of queens is likely different from where they forage and nest, both spatially and in terms of habitat characteristics (Darvill et al. 2004, Waters et al. 2011, O'Connor et al. 2017; Williams et al. 2019). Overwintering sites are generally underground, most often in shaded areas near trees as well as in banks without dense vegetation and in areas with tree litter, moss, or in bare patches within short grass (Figure 4; Sladen 1912, Plath 1927, Bols 1937, Hobbs 1965a, 1965b, 1967, Alford 1969). The closely related buff-tailed bumble bee (*B. terrestris*) reportedly overwinters beneath trees (Sladen 1912).

Overwintering queens have most often been found on north-facing slopes, likely to prevent early emergence on warm, sunny winter days; queens may also overwinter on slopes with other aspects or on flat ground (Sladen 1912, Plath 1927, Bols 1937, Hobbs 1967, Alford 1969). Overwintering sites most often occur in sandy, well-drained, or loose soil (Bols 1937, Plath 1927, Hobbs 1967, Alford 1969). Queens overwinter at varying depths within the soil to regulate their temperature and emerge at the optimal time (Hobbs 1966a, 1965b, 1966b, 1967, Alford 1969, Szabo and Pengelly 1973).

Limiting Factors

The primary threats to western bumble bees in Washington include pathogens from managed (commercial) bumble bees and honeybees; competition from managed bees; impacts from reduced genetic diversity; habitat alterations including conifer encroachment (caused by fire suppression), overgrazing, agricultural intensification, urban development, and logging; exposure to pesticides; fire; and climate change (Lamke et al. 2020). A brief review of these threats is provided below.

Depending on the scale and scope of the threat, many of these factors can pose significant harm but also can provide some benefits to bumble bees. For example, the degree to which fire poses a threat to bumble bees depends on fire intensity, size, and timing. Some fires can cause long-term catastrophic damage, while others may generate beneficial habitat in the near- and long-term (Galbraith et al. 2019). Urbanization, while broadly negative, may also have positive effects on bumble bees when compared to other land conversions including monocultural agriculture (Hall et al. 2017). The range of impacts of these potential threats highlight the importance of land management to support at risk species.

Pathogens

Commercial bees can transmit pathogens to wild bees when sharing the same flowers (Nanetti et al. 2021, Colla et al. 2006). Research on North American bumble bees shows higher rates of infection in western bumble bees with the fungal pathogen *Vairimorpha bombi* (previously classified as *Nosema bombi*) than for non-declining bumble bee species (Cameron et al. 2011b). Although *V. bombi* is native to North America, the level of infection has increased in wild bumble bees after the introduction of commercial greenhouse colonies (Cameron et al. 2011b). Commercial bumble bees, such as the common eastern bumble bee (*B. impatiens*), have escaped commercial greenhouses in Washington (Looney et al. 2019). These bees that have established in the wild were infected with *V. bombi* and may have increased the amount of fungus in the environment (Cameron et al. 2016, Colla and Ratti 2010, Bumble Bee Watch 2022). Pathogens and parasites from other sources, such as RNA viruses from honeybee colonies (Singh et al. 2010), also threaten wild bumble bees (Colla et al. 2006, Otterstatter and Thomson 2008, Murray et al. 2013).

Genetic Impacts

Recent dramatic declines in the range and relative abundance of the western bumble bee may reduce the genetic diversity of the species. Research indicates that western bumble bee populations have lower genetic diversity compared to populations of co-occurring stable species (Cameron et al. 2011b, Lozier et al. 2011). The loss of genetic diversity could make the species more susceptible to harmful pathogens and could increase their vulnerability to extinction (Altizer et al. 2003, Whitehorn et al. 2009). It also could contribute to what is called an extinction vortex, a spiral of factors leading to decreased fitness, and potentially extinction (Zayed and Packer 2005).

Habitat Loss and Degradation

Modifications to bumble bee habitat from overgrazing by livestock (reviewed in Hatfield et al. 2012), agricultural intensification (Williams 1986, Carvell et al. 2006, Diekötter et al. 2006, Fitzpatrick et al. 2007, Kosior et al. 2007, Goulson et al. 2008), urban development (Bhattacharya et al. 2003, Jha and Kremen 2013), conifer encroachment resulting from fire suppression (Panzer 2002, Schultz and Crone 2008, Roland and Matter 2007), and fire (Brown et al. 2017) also threaten western bumble bees. Overgrazing by livestock can be particularly harmful to bumble bees by removing floral resources, especially during mid-summer when flowers may already be scarce (Hatfield and Leben 2007, Hatfield et al. 2012). Grazing can also alter hydrology and soils, increasing bare ground, erosion, and compaction (DeBano 2009, Schmalz et al. 2013). Conversion of natural habitat to impermeable surfaces, such as often the case with development, similarly decreases the availability of floral resources as well as areas suitable for nesting and overwintering. Additionally, landscaping in urban areas frequently includes large areas of turf grass that do not provide floral resources.

Pesticides

Many pesticides pose both lethal and sublethal threats, as well as direct and indirect threats to bumble bees, even when legal application requirements are followed. Herbicides can remove floral resources and fungicides are linked with subtle harm such as decreases in the number of offspring, lethargy, and decreased foraging (Bernauer et al. 2015). Insecticides, many of which are designed to kill a broad spectrum of insects, can pose a direct threat to bumble bee health. Broad spectrum insecticides are commonly used in agricultural and urban landscapes for controlling insect pests. Of particular concern are the widely used neonicotinoid insecticides and other systemic insecticides. Systemic insecticides are expressed in the nectar and pollen of plants and are therefore actively eaten and collected by bumble bees, as well as fed to developing larvae (Hopwood et al. 2016). These insecticides can persist in the environment and in plant tissues at toxic levels for months to years after their application and exert both lethal and sublethal effects on bumble bees (Whitehorn et al. 2012, Hopwood et al. 2016).

Climate Change

Recent evidence suggests that climate change is causing landscape scale effects that lead to a decline in suitable habitat for bumble bee populations, particularly at high altitudes (Kerr et al. 2015, Miller-Struttmann et al. 2015, Fourcade et al. 2019, Koch et al. 2019). Climate change is also likely to exacerbate urban heat island effects, which will impact western bumble bees in developed landscapes (Grossman-Clarke et al. 2017, Baldock 2020). The impacts of climate change on pollinator communities, particularly in arid and semiarid regions of the western United States, is projected to increase (Perry et al. 2012, IPCC 2022). As temperatures continue to rise and droughts become more intense and frequent, the amount of precipitation and timing of available moisture will continue to change (Kwon et al. 2018, Cartwright et al. 2020). This will continue to alter the timing and distribution of plant and pollinator communities, leading to potential mismatches between plants and pollinators (Parmesan 2006, Perry et al. 2012, Miller-Struttmann et al. 2015). Since many of the areas where the western bumble bee is currently found are in higher elevation sites throughout Washington, the species may be particularly susceptible to the effects of climate change.

Management Recommendations

Identifying Western Bumble Bee Habitat

Because bumble bees are physically small and spend much of their life cycle (Figure 3) in highly concealed nests and overwintering sites, many western bumble bee populations across Washington are not recorded. This presents a challenge when addressing the conservation of this species given that the location of all populations of western bumble bees have not been determined. Relying solely on recorded observations of the species has the potential to limit effective conservation of this declining species.

To address the lack of recorded observations and difficulty of detection, we recommend flagging land use proposals for additional assessment within 10 km of a known western bumble bee observation. This allows for the assessment of not only areas with known presence of the species, but also in areas where the likelihood of finding western bumble bees is high. The specific process for flagging and assessing sites is described later in this section. We used a 10 km buffer because it is approximately the farthest distance that bumble bees have been recorded to travel from their nest (Williams et al. 2014). The U.S. Fish and Wildlife Service also has identified this distance as the scale at which bumble bee populations exist (USFWS 2020).

This publication also relies on the modeled distribution of western bumble bee to identify potential habitat. The distribution modeling (Phillips et al. 2022) for western bumble bee considers recent recorded observations of the species, as well as a variety of climatic variables (Booth et al. 2014), elevation, and projected land use and land cover (USGS 2022). The species distribution model (SDM) can also be interpreted as the distribution of habitat suitable for the species. While the areas identified in the model can be used to broadly identify zones with suitable habitat for the western bumble bee, the procedures described in the following sections will help assessors make decisions regarding impacts to the western bumble bee and other pollinators.

Countywide Assessment

An initial step that county and municipal land use planning agencies should take is to verify if their jurisdictions include areas with a reasonable chance of western bumble bee occurrences. The map in Figure 5 classifies each of Washington's counties by their level of conservation priority for western bumble bee as determined by the SDM. Counties and cities that fall within areas of medium to high conservation priority should adopt measures into their local plans and regulations to protect and mitigate the impacts of land use activities on western bumble bee habitat. Such measures should be included in critical area ordinances, comprehensive plans, as well as other local plans and regulations. Refer to the section titled "Guidance for Community and Long-range Planning Programs" for suggestions on integrating measures into local plans and regulations to effectively address western bumble bee conservation. Land use proposals in low conservation priority counties should also be reviewed and assessed when located near known occurrences of occupied western bumble bee habitat (Figure 6).

Site Assessment

At a finer spatial scale, the following sequence of steps will help to decide when a land use proposal is in an area with characteristics of western bumble bee habitat. Counties and municipalities identified in Figure 5 as being medium to high conservation priority should follow the sequence of steps described below whenever a land use activity is proposed. Counties identified as being low conservation priority may also follow these steps.

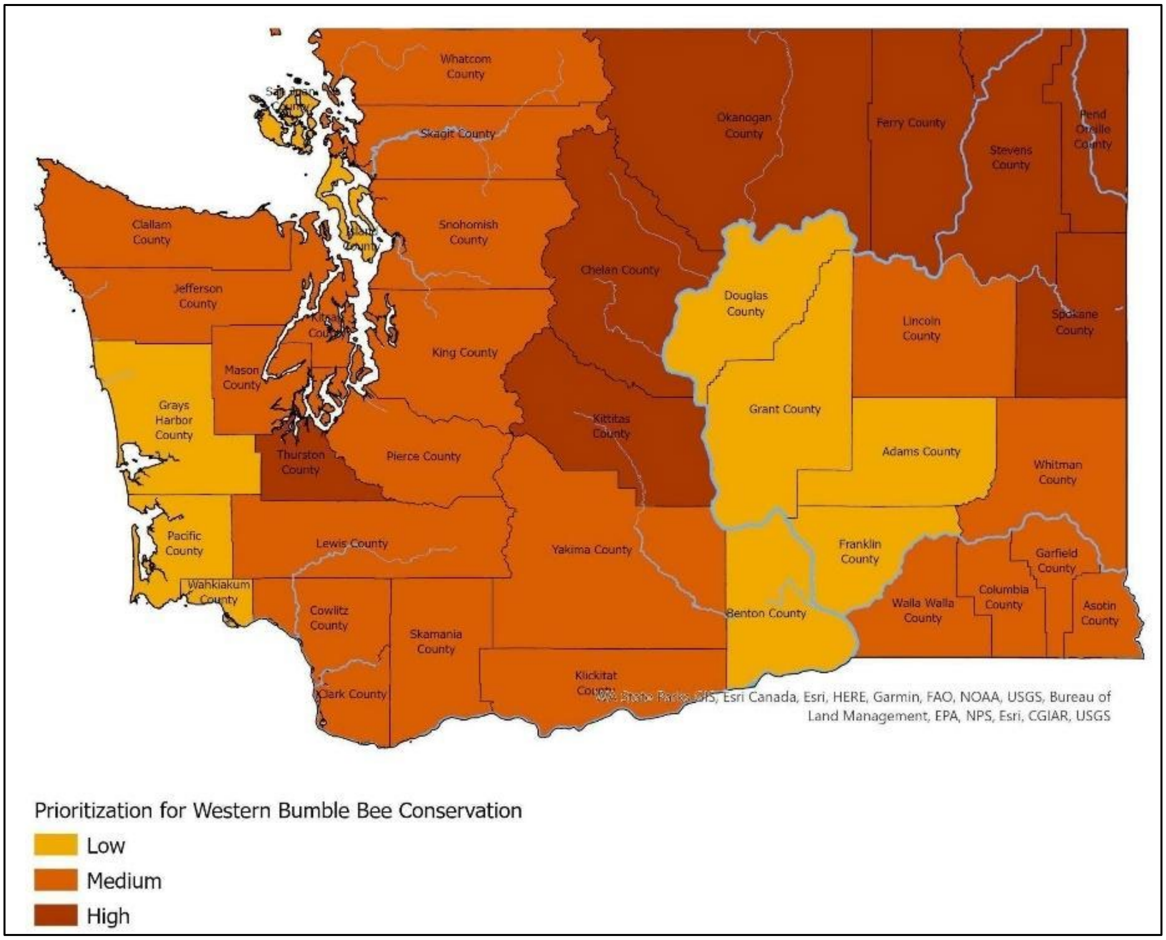

Figure 5. Prioritization for western bumble bee conservation by county. Priority is based on the recent (2011 through 2021) likelihood of western bumble bee occupancy as determined by species distribution modeling.

The steps start with a coarse-scale assessment that does not require a site visit. Subsequent steps do require site visits, as well as progressively more detailed ground truthing. Each step in the sequence requires answering a "yes" or "no" question. A "yes" response directs the respondent to a successive step in the sequence. This sequence of steps will help determine when there is suitable western bumble bee habitat on a site or parcel. It also helps determine when and how to mitigate impacts in suitable habitat. Because western bumble bees are generalist pollinators, the sequence of steps will also help to determine where there is habitat for other generalist bumble bee species.

The following describes a sequence of three steps for determining if a site should be mitigated to protect habitat for western bumble bees.

Step 1. Coarse Assessment

Start by determining if the proposed activity is within 10 km of a recent observation of western bumble bee. This can be done by identifying the location of the proposed activity on this interactive online map (Figure 6 shows a screenshot of the interactive map). If the map shows that the proposed project is within one of the darker red circles, the next step will be to conduct a rapid assessment of the parcel. A rapid assessment requires an on-site visual survey of the parcel. This step requires only a very coarse survey and will not require collecting any detailed or elaborate measurements. For this reason, it will not require any specialized skills other than a general background in doing rapid ecological assessments.

Step 2. Rapid Assessment

Walk throughout the entire parcel(s) where the land use activity is being proposed to determine the presence of any of the three characteristics described in Table 1. This is done through a rapid assessment of the site by estimating the proportion of the parcel covered by species of flowering plants as well as looking for other features specified below (e.g., undisturbed bare ground). The surveyor assessing the site should be trained and skilled in identifying plants native to the region as well as common exotic and invasive plants.

Table 1. Characteristics to assess during rapid assessment.

1. Is at least 10% of the site, excluding paved areas and buildings, composed of flowering forbs, shrubs, and trees? Areas composed of flowering plants include all plants that provide flowers, whether they are currently in bloom or not. Flowering plants can include any flowering forbs, shrubs, or trees. Use canopy cover, or total area of influence of a plant ignoring gaps in the canopy, to estimate percent cover.
2. Are there at least four species of native plants in flower continuously throughout the bumble bee flight period (will vary by location)? The species flowering at any given time may vary, but at any point four species should be simultaneously in bloom. More than one survey taken during different times in the growing season will likely be necessary to make this determination.
3. Are there undisturbed areas of bare ground and/or natural areas (e.g., leaf litter, wood, rock piles, rodent burrows, or grass tussocks) where bees may nest and/or overwinter on the parcel(s)?

A rapid assessment requires a thorough walk through of the entire parcel to estimate if any of the previous three site characteristics are present. If your answer is “yes” to at least two of these three questions above, then we next recommend doing a survey of the parcel(s) to look for western bumble bees and their nests.

Alternatively, if you answered “no” to two or more of the questions above, then no more action is needed. However, this result should not discourage the property owner from taking voluntary actions to improve pollinator habitat on their land, including for the western bumble bee. A variety of Xerces Society publications are available to help create and improve pollinator habitat. Please see the "*Additional Resources for Pollinator Habitat Management*" in Appendix 3 for guidance.

Step 3. Western bumble bee site survey

A survey should be conducted by a qualified biologist with expertise or training pertaining to the identification, ecology, and surveying of bumble bees. The protocol used for these surveys has been adapted from the Pacific Northwest Bumble Bee Atlas Project. A full description of the project's protocol can be found at https://www.pnwbumblebeeatlas.org/point-surveys.html. The following protocol as

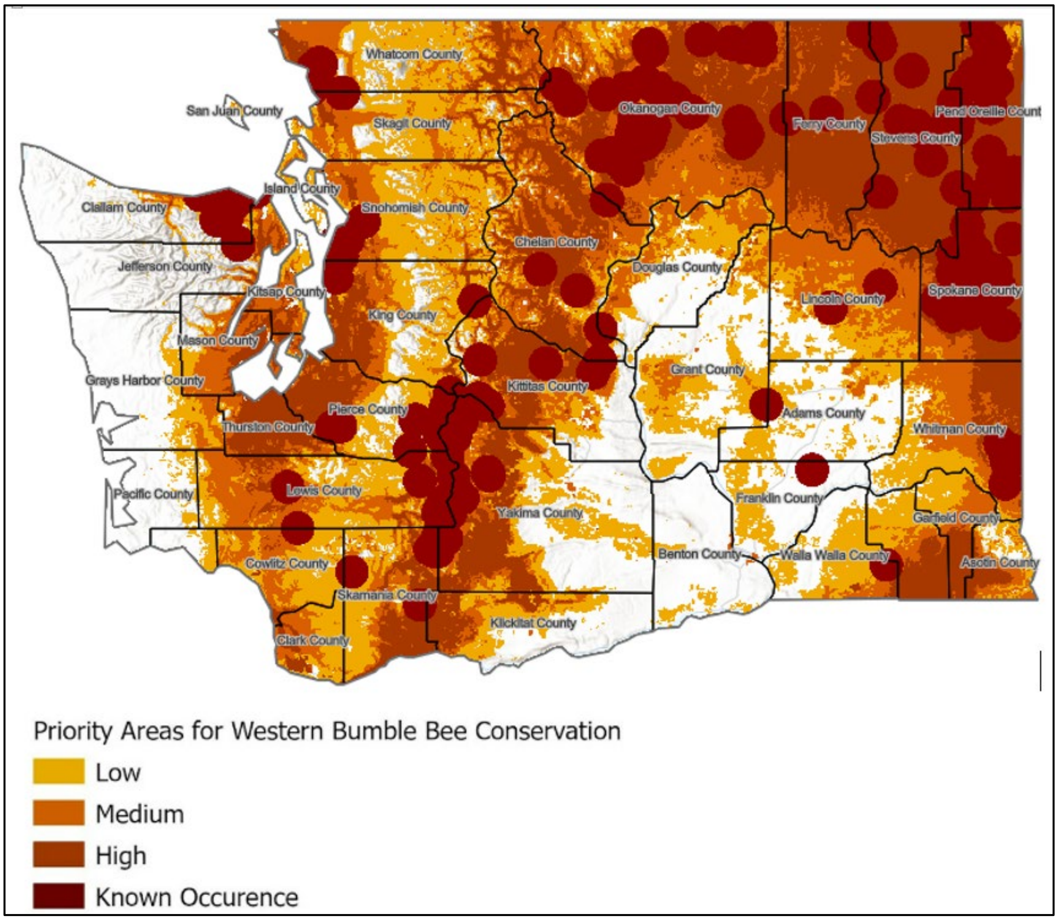

Figure 6. Priority management areas for the western bumble bee based on the recent (2011 through 2021) species distribution model and 10 km buffers around recent observations of the species.

well as information available through the Pacific Northwest Bumble Bee Atlas Project may be used to gain the knowledge necessary to complete the recommended surveys. Experience using global positioning systems and mobile devices to map the sampling site boundary and collected bees is also necessary. Recommended materials for the western bumble bee site survey are as follows:

- Site map showing the boundary of the surveyed parcel(s) divided into one hectare survey blocks.

- GPS or smart phone with GPS capability
- Data sheets
- Pencils
- Camera with macro function or smart phone
- Insect net
- Small cooler with ice (not “blue ice” or other chemical chilling agents)
- Vials
- Materials for sanitizing vials (alcohol, alcohol wipes, or diluted [10%] bleach solution)
- Bumble bee identification guide
- Plant identification guide

The site survey involves collecting bumble bees using a net. There is no need to collect individuals with markings that clearly distinguish them as a species other than western bumble bee (e.g., individuals with patches of orange or rusty-colored hairs).

All surveys should occur during the optimal time of year and day. Sites should be surveyed during the active season and during the period of peak detection or as close to that period as possible (Figure 3). In most of Washington, the peak detection period is in July and generally corresponds with the peak in floral abundance.

Surveying during the correct time of day and on days with suitable weather conditions is also important. All surveys should occur between midday and late-afternoon (11am - 5pm) when temperatures are between 60-90 degrees Fahrenheit, with winds averaging no more than 15 miles per hour, and when there is no precipitation. Surveying during daylight hours either earlier (before 11am) or later (after 5pm) in the day is acceptable when temperatures are more than 90 degrees for extended periods between 11am and 5pm.

The survey should be conducted on any parcel(s) where a land use activity is proposed. The entirety of the parcels should be surveyed twice, on two separate days during the peak period. Repeating the survey on two days decreases the odds of missing western bumble bees that are using the site. The survey generally will follow a similar protocol to the Pacific Northwest Bumble Bee Atlas Project. The primary difference is that instead of searching for all species of bumble bee, the survey will only focus on western bumble bees.

Parcels surveyed should be divided into one hectare (100 meter by 100 meter) survey blocks. This is equivalent to around 2.5 acres. Parcels or sites less than this size can be considered one survey block. The boundary of each survey block should be mapped in GIS and given a unique identification number.

Each block should be surveyed for western bumble bees for a period of 45 person-minutes. A single surveyor requires 45 minutes to complete a survey, while two people can complete a survey in 22.5 minutes, and three require only 15 minutes per individual. Before surveying a block, fill in the survey/weather information at the top of the data form in Appendix 4. This will include the survey block number, date, time, name of surveyor(s), temperature, cloud cover, wind speed, as well as the other information indicated on the form. Complete a separate data sheet for each block surveyed. Note the survey start time on the data sheet, begin your timer, and start searching for bumble bees.

The survey should cover the full area of each survey block, although more time should be spent searching in areas with high floral abundance than in areas with fewer flowers. Pay attention for bees visiting inconspicuous flowers that are green, small, or low growing. Bees flying close to the ground may be searching for a nest. Nesting features include abandoned rodent burrows and other natural or artificial cavities, including in clumps of grass (e.g., bunchgrasses), hollow logs, and brush/rock piles. Nests are difficult to find, but if a nest is found, collect a bumble bee from the nest and record it as a nesting bee by checking the box on the data sheet. Take a GPS location of the nest site and record the location on the data sheet alongside the record of the specimen taken from the nest.

Capture bumble bees using a net and place each bee into an individual vial. Pause the timer each time you capture a bee. With the timer paused, mark the vial using a unique identifier and take a photo of the vial with the host plant that the bee was associated with. Record onto the survey form the identification number for each of these photos. Now place each vial into a cooler packed with ice (do not use "blue ice" or other chemical chilling agents, ice cubes are the safest method). The ice will cool off the bees enough that their movements are slowed, and you can clearly photograph them. Record onto the survey form the latitude and longitude of each bumble bee collected after taking a GPS reading of their location. Now restart the timer until you capture another bumble bee.

Once you have completed surveying a block (having searched an entire survey block for a total of 45 person-minutes), photograph each bee that you captured. Do this by removing a single bee at a time, ensuring that they are either not moving or only moving very slowly. Then take at least three photos to document the full color pattern on the bees' face, thorax, abdomen, hind legs, and cheek. Photos should be close up and in focus. For more information on photographing bumble bees, visit the Pacific Northwest Bumble Bee Atlas' Photography Tips webpage.

Record onto your data sheet the photo identification number(s), associated host plant, and the name of bumble bee species. If you are unable to identify the species of plant or bumble bee species in the field, that information can be filled in later using the photographs for identification. Repeat the process in each of the survey blocks.

Sanitize all vials between uses to avoid transmission of pathogens. Sanitize with alcohol, alcohol wipes, or diluted (10%) bleach solution and allow vials to dry completely before reuse.

After surveying all blocks within a parcel, attach an aerial photo of the site to the completed data sheets. The aerial photo should show the property boundary along with the boundary of each of the survey blocks labeled with their survey block numbers. These photos should preferably be submitted to a trained, professional taxonomist for identification. The taxonomist can review the set of photos for each specimen, identify whether any individuals are western bumble bees, and if so record the species name next to the associated photos. The trained biologist who performed the western bumble bee site survey can also carry out species identification when no taxonomist is available. In this scenario, we recommend that the surveyor be trained in identifying western bumble bees as well as any other similar looking species.

The most common color pattern for a western bumble bee in Washington State includes a black face and vertex, yellow band across the front of the thorax, and white across the rear portion of the abdomen. This color pattern, particularly the white on the abdomen, is unique to this species in

Washington and easily distinguishes it from other bumble bee species. See Appendix 5 for illustrations and photographs of the western bumble bee.

If any western bumble bees are documented within the parcel the next step is to conduct a habitat assessment. A habitat assessment will inform how to mitigate negative impacts on western bumble bee habitat and is described in detail in the following section.

If no western bumble bees are documented, no further assessment or mitigation measures are recommended. Report the absence of western bumble bee detections to the local planning authority and submit this information with the land use or development application.

Even if no western bumble bees are documented, taking steps to mitigate project impacts on pollinator habitat is still encouraged. This can include siting land use activities and disturbances to areas already more impacted by disturbance or by enhancing or introducing characteristics of pollinator habitat onto the property (see Best Management Practices below for guidance).

Habitat Assessment

A habitat assessment requires collecting quantitative and qualitative data. Information gathered in the habitat assessment will help to establish a parcel's habitat characteristics for bumble bees. Although the habitat assessment is designed to characterize a site's value to bumble bees in general, the assessment is very useful to identify what habitat features or land use practices can be improved to benefit generalist pollinators such as western bumble bee. The outcome of the assessment is also useful to identify ways to mitigate potential negative impacts of a land use proposal. This can include helping to direct disturbances to locations that are less suitable as pollinator habitat. The process for carrying out a habitat assessment is found in Appendix 6 and is a modified version of a habitat assessment designed by The Xerces Society (2018).

The habitat assessment should be conducted by an expert trained in identifying plants native to the region as well as non-native plants found in the region. An understanding of the ecology of native pollinators is also useful for conducting a habitat assessment. The assessment should be carried out on the entire parcel using the stated methods.

The habitat assessment measures attributes of foraging, nesting, and overwintering habitat. For foraging habitat, the parameters require gathering on-site data of density and diversity of flowering plants. Because many pollinators, including western bumble bees, benefit from continuous flowering throughout the active season (Figure 3), the survey requires characterizing the number of species and density of flowers in bloom during spring, summer, and fall. This usually necessitates at least one visit during each of the three seasons to adequately document the full community of flowering plants.

For nesting and overwintering habitat, the assessment requires a survey to characterize features on site where these activities can occur.

Mitigation

Mitigating the negative impacts of development on western bumble bee habitat should be guided by the results of the habitat assessment. A habitat assessment will help to identify features on the property likely to contribute to functional habitat for generalist pollinators such as western bumble bees. This type of information can then guide the development of a plan to mitigate for project impacts to pollinator habitat.

The most effective way to support bumble bees is by protecting their foraging, nesting, and overwintering habitat, and by limiting land-use changes to important habitat and by keeping these habitats free from pesticides, pathogens, and other impacts. We recommend that users of this document follow the mitigation sequence when evaluating a project in habitat used by western bumble bees. The mitigation sequence is a framework of alternative actions that a land use applicant should consider to reduce a project's negative impacts. These alternative actions are listed in order of preference:

- **Avoiding** impact altogether by not taking a certain action.
- **Minimizing** impacts by limiting the degree or magnitude of the action and its implementation by using appropriate technology, or by taking affirmative steps to avoid or reduce impacts (e.g., habitat restoration).
- **Compensating** for the impact by replacing, enhancing, or providing substitute resources or environments.

The following sections provide guidance to avoid, minimize, and compensate for the negative impacts of development on western bumble bee habitat.

Avoiding

The first alternative action in this framework requires an applicant to determine if they can avoid impacts to the site altogether. In this framework, avoidance is always the first action to consider because it is the preferred approach to conserving habitat, including habitat occupied by the western bumble bee.

Minimizing

The second alternative is to minimize the negative impacts of a project on western bumble bees. Minimization should only be implemented after thoroughly considering all avenues to avoid impacts altogether. Project planners and developers at a minimum should aim to achieve a standard of no-net-loss of habitat function when devising a plan to minimize impacts. Although no-net-loss should be the minimum standard, the preferred standard is net-ecological gain, given that western bumble bee is an imperiled species that will likely require a greater amount of functional habitat in Washington to reverse population declines. Later we describe a strategy for measuring habitat function using the results of the habitat assessment described in the previous section.

The information in this section along with the information on developing a habitat management plan (HMP) in the next section should be used together to create a plan to minimize negative habitat impacts. An HMP should be designed to identify the strategies that the project applicant will take to minimize the impacts of their project. Common strategies include reducing the project's footprint and intensity, siting a project further away from higher quality habitat, creating or restoring habitat, or using low impact development practices. A successful strategy will ultimately be designed around the site-specific opportunities to benefit the species.

Often there will be more opportunities to mitigate negative impacts on western bumble bee when a parcel is either relatively large or when it consists of varying levels of habitat quality. Options to minimize impacts may be more limited on smaller parcels or on parcels with less varied habitat, and especially on parcels that are entirely made up of high-quality habitat. Parcels almost entirely comprised of higher quality habitat or where options to minimize impacts are limited should be strong candidates for taking a strategy of avoiding impacts altogether.

Habitat Management Plan

Planners and developers should attempt to develop an HMP for parcels where there are available options to minimize impacts. An HMP (often called a Critical Area Report), when implemented, should at a minimum result in no-net-loss of western bumble bee habitat function. Although habitat function cannot be precisely measured, known attributes of quality habitat can be used to generate useful estimates. The results and scoring generated from the habitat assessment described earlier can serve as an important guide for measuring habitat quality and function, as well as the potential for land use activities to negatively affect local western bumble bee populations. The results of a habitat assessment will also help determine habitat deficiencies that can then be improved through mitigation measures.

A template for developing an HMP is provided in Appendix 7. In developing an HMP, use the information gained from the habitat assessment to guide what strategies will effectively reduce impacts to habitat used by western bumble bees. The overall scores from the habitat assessment can be used as a general guide for what mitigation strategies might be most appropriate to the site. We also recommend mapping where flowering plants are located on the parcel and including this map with the HMP. Mapping locations of where bumble bees, including western bumble bees, were recorded is also useful and should be included as part of the HMP. These types of maps showing where there are floral resources and bumble bees will be useful to identify where on a parcel there are features that should be avoided and not disturbed. As a guide in Table 2 we recommend the following strategies based on the corresponding range of scores.

Table 2. Generalized recommended strategies for minimizing impacts based on a parcel's corresponding score in the habitat assessment[1].

Score	Strategy
0 - 55	The suitability of the area for supporting pollinators is low. Resources should be directed towards habitat restoration to increase the elements of the habitat that support native pollinators.
56 - 105	The suitability of the area for supporting pollinators is moderate. Resources should be directed toward both habitat restoration and maintaining the elements of the habitat that support native pollinators.
106 - 160[2]	The suitability of the area for supporting pollinators is high. Resources should be directed toward maintaining the elements of the habitat that support native pollinators.

These ranges provide some direction for recommended mitigation. The specific actions taken will depend on the on-site needs to maintain or enhance habitat for western bumble bee. The overall HMP should be designed to retain or, even better, increase the site's overall capacity as habitat for generalist bumble bees such as the western bumble bee. This can be done by implementing strategies that, at a minimum, retain or increase the site's overall habitat assessment score once development and mitigation activities are implemented. Scores within the habitat assessment can also be used to see where to target mitigation actions. For example, a low score for foraging habitat can indicate a need to focus some mitigation on enhancing foraging habitat.

The following guidance and best management practices for maintaining high quality pollinator habitat, derived from peer-reviewed literature, have been adapted from Hatfield et al. (2021b). These should be used as guidance as well when developing an HMP, along with other resources for habitat assessment, installation, and management that are found in Appendix 3.

Best Management Practices

Keys to success when designing an HMP:

- Site preparation is vital: attempting to restore or enhance highly degraded sites is a long-term project that is ill-advised without a long-term monitoring and maintenance plan.
- Consider forb plugs instead of, or in addition to, forb seeds. While plugs may be more expensive in the short-term and can require irrigation, they often result in better habitat and increased project success.

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1 These scores are generated using the habitat assessment mentioned earlier and found in Appendix 6.

2 Parcels with scores approaching the higher end of this range may be good candidates for taking a course of action to avoid the impacts altogether (see "Avoiding" section above).

- Native plant seed and plugs are often in limited supply. Plan and work directly with plant materials providers to support availability of desired plants.

General principles to consider in your HMP

- Minimize and set aside high-quality and undisturbed western bumble bee habitat whenever possible. In urban and semi-urban settings, prioritize natural, undisturbed green spaces (e.g., natural parks, native gardens, natural roadside habitat) instead of managed green spaces (e.g., golf courses, managed lawns).
- Use mitigation (see Mitigation section).
- Maximize habitat connectivity when creating habitat and when looking for compensatory mitigation sites.
- Prioritize locally adapted native plants and avoid pesticides.
- Avoid ground disturbing activities in high-quality nesting habitat, particularly from March to September when bumble bee colonies are active and the destruction of a nest could eliminate thousands of individuals and hundreds of potential future colonies.
- Treat, at any given time, no more than a third of an overall site or habitat feature (foraging, overwintering, or nesting habitat) when conducting any type of destructive treatment (e.g., mowing, burning, or grazing).
- Use adaptive management strategies.

Invasive plants

- Preventing spread of invasive plants requires far less work than eliminating invasives once established. Prioritize using native plants. Avoid moving soil, hay, or other exotic plant seed sources long distances.
- Consider a variety of targeted controls of invasive plants (mechanical, biological, cultural, and chemical).
- Minimize pesticide exposure to non-target plants and animals.
- Use a phased approach (no more than a third of a site at a time) to avoid removing much of the floral resources all at once. Bumble bees are likely dependent on floral resources from invasive plants, and when they are removed, they need to be replaced as soon as possible to avoid local population declines. If a species is non-native but not invasive, and is frequently visited by bumble bees, removing it may not be a priority.
- Create a revegetation plan on a timeframe that replaces the food on which pollinators have been dependent.
- When using herbicides:
    - Use selective herbicides for targeted invasive plant(s), when available.
    - Avoid broadcast applications.
    - Train staff or contractors in plant identification so they know what plants not to treat.
    - Do not spray when targeted plants are flowering.

Mowing and haying

- Reduce mowing frequency to allow flowering plants to bloom. Bee abundance is significantly higher on lawns mowed every other week rather than every week (Lerman et al. 2018).

- Avoid early spring and mid-late summer mowing when flowering resources are present (protects queens at a vulnerable stage). Lawns where mowing is suspended for a single month in the spring have been shown to support three-times higher bee species richness and five-times higher bee abundance than nearby mowed areas (Del Toro and Ribbons 2020).
- If you must mow during the flight period for bumble bees, try to leave islands of habitat (ideally two–thirds of the site during each mowing event) to create a mosaic pattern with refuge sites; and leave some areas (especially boundaries) entirely unmowed for the entire year, if possible.
- Fall mowing after the first frost is best.
- Set the mower at its highest height.
- Consider increasing the habitat value of areas of primarily managed grass by adding more flowering species. A "bee lawn" may include Dutch clover (which captures nitrogen and helps feed the lawn) as well as other low-growing flowering plants such as creeping thyme (*Thymus* spp.), self-heal (*Prunella vulgaris*), and others. Some plants, such as native violets (*Viola* spp.) may already be present and should be encouraged.
- In urban areas, managers can support the creation and enhancement of pollinator habitat by ensuring ordinances governing landscaping of residential and commercial properties, parks, medians, and property along trails and roads allow for infrequent mowing and tall vegetation to the extent possible.

Managed honeybees

- Managed honeybee operations should not be permitted within 6.4 km of areas where western bumble bees occur or on protected natural lands including designated wilderness, national parks and monuments, or state preserves.
- Find additional information and resources related to managed honeybees in Appendix 3.

Management of foraging habitat

Replacing Existing Foraging Habitat:

- Avoid removing flowering plants whenever possible.
- Activities that impact vegetation should not occur within 10 meters of foraging habitat.
- If native flowering plants must be removed, prioritize planting the same species in a similar or greater quantity and density in a nearby location and replace non-native species with native species with a similar blooming period (see Appendix 2 for plant selection references).

Supplementing or Improving Foraging Habitat:

- Maintain a diverse community of plants that flower in the active season (Figure 3), including a diversity of colors, shapes, sizes, and plant structure.
- Establish plenty of flowers that bloom in early spring for colony initiation and in late summer when flowers are more limited. Early nectar and pollen sources include Oregon grape (*Berberis* spp.)*, winter currant (Ribes sanguineum*)*,* and bearberry (*Arctostaphylos uva-ursi*) among others in western Washington. In eastern Washington, they include Oregon grape (*Berberis* spp.)*, sticky gooseberry* (*R. viscosissimum*)*,* Canadian gooseberry (*R. oxyacanthoides*)*,* golden currant (*R.*

aureum), and bearberry among others. Native willows also provide early nectar and pollen throughout Washington.

- Establish plants often used by the western bumble bee. In Washington these include plant species in the genera: *Centaurea, Cirsium, Spirea, Lupinus, Lavandula, Solidago, Chamaenerion, Anaphalis, Hypericum*, and *Origanum* (Hatfield et al. 2021a).

General Guidelines for Foraging Habitat:

- Prioritize native plants or regionally appropriate noninvasive plants when stocks of native plants are unavailable. Avoid horticultural varieties that may not produce as plentiful or high-quality nectar and pollen.
- Plant native flowering trees with foraging resources, particularly ones that flower in spring and late summer.
- When creating foraging habitat in arid landscapes, choose plants tolerant of extreme climate.
- Select seeds and seedlings not treated with pesticides, particularly systemic insecticides.
- Avoid insecticides and broadcast herbicides in bumble bee foraging habitat.

Find additional resources for plant selection in Appendix 2.

Management of nesting and overwintering habitat

General Guidelines for Nesting Habitat:

- Avoid ground-disturbing activities that may harm nests and overwintering sites. Ground disturbing activities including excavation and road building should not occur within 10 meters of known nests or overwintering sites.
- If ground disturbances must happen in potential overwintering habitat, limit construction to seasons when queens are not overwintering (Figure 3).
- Maintain at least 50% of the site in natural or semi-natural habitat (e.g., not impervious surfaces, managed lawns, or other manicured landscaping).
- Because western bumble bees depend on burrowing mammals for nesting sites, keep areas around burrows undisturbed.
- Maintain undisturbed microhabitat features including moss, leaf litter (broad leaves and evergreen), and loose organic material in the vicinity of foraging habitat. Do not cover bare soil, even with loose wood chips.
- Preserve structural complexity, including downed wood, rock piles, and tall grasses.
- Leave portions of fields unmown to avoid impacts to bumble bees nesting.
- Extend land management for bumble bees to at least 100 meters into habitats beyond what might traditionally be considered high quality pollinator habitat (e.g., woodlands and forests).
- Avoid applying insecticides to bumble bee nesting habitat.

Compensation (Compensatory Mitigation)

The last alternative in mitigation sequencing is compensatory or off-site mitigation. This should only be used after all other opportunities for on-site mitigation have received serious consideration and are deemed unfeasible. This is the least preferred alternative from a conservation standpoint because it will result in habitat loss and will likely harm or destroy western bumble bee colonies. Because western bumble bee is a species in decline, sites secured elsewhere to compensate for lost habitat should be larger than the site being replaced. We recommend that for every acre of habitat converted, two acres be secured and protected somewhere off-site. Off-site mitigation can also be combined with minimization, especially when actions to minimize impacts on-site cannot achieve no-net-loss of habitat function.

Compensatory mitigation should occur as close in proximity as possible to the parcel being replaced. Sites considered as off-site replacement habitat should undergo a habitat assessment (Appendix 6). The following are selection criteria for identifying an alternative site suitable to provide off-site mitigation:

- ✓ Habitat Assessment score should be higher on the mitigation site than on the replaced site.
- ✓ Mitigation site should preferably be within 10 km from the replaced site and no more than 20 km away.
- ✓ Mitigation sites adjacent to other conserved properties are preferred.
- ✓ Recommend a 3:1 mitigation ratio for mitigation sites greater than 20 km from replaced site.
- ✓ Mitigation site is adjacent to properties that are free of major invasive vegetation species infestation, or existing infestations are being and would continue to be managed, such that they are not anticipated to pose a significant risk to the mitigation site's function as pollinator habitat.
- ✓ Mitigation site is well connected to other areas of natural or semi-natural habitat.
- ✓ Mitigation site has little or no artificial impervious surfaces.
- ✓ Mitigation site will not require long-term maintenance to sustain targeted habitat functions.

Mitigation sites secured to replace lost or degraded habitat should be protected with a conservation easement or a comparable legal instrument in perpetuity. The easement or comparable legal instrument should be put into place before any portion of the replaced site undergoes construction or other disturbances. The legal documentation must, to the extent appropriate and practicable, prohibit incompatible uses on the mitigation site that might otherwise jeopardize the objectives of the compensatory mitigation project.

Guidance for Community and Long-range Planning Programs

This section provides guidance to help local governments review, develop, and implement regulatory tools to protect western bumble bee habitat. Local governments should regulate land use activities likely to impact western bumble bee habitat to ensure, at a minimum, that existing functions and values are protected from development. This can be accomplished by including language in local critical areas ordinances to require the use of maps of known occurrences of western bumble bees. These maps should be used to flag projects near areas of known western bumble bee populations (see maps at https://arcg.is/9P01m). The critical areas ordinances should also describe the process for assessing the impacts of projects that have been flagged to verify its function as habitat for western bumble bees. For that, we recommend referring to the process outlined in our recommendations for conducting a habitat assessment and for using the results of that assessment to inform mitigation actions, including the development of an HMP, that when implemented, will achieve at a minimum no-net-loss of habitat function on the site being developed.

We also strongly advise having a process in place, so all departments involved in permitting any part of a project proposal (e.g., building, clearing and grading, utilities) on a site flagged for western bumble bees are aware of any related conditions or regulations in the local critical areas ordinances.

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Appendices

Appendix 1. Detailed methods used for data analysis and visualization.

Data

Occurrence records were sourced from a database of more than 200,000 records of 43 species of North American bumble bees compiled from various collections, research projects, and other datasets, originally developed in 2014 (Williams et al. 2014) and maintained by Dr. Leif Richardson (Richardson 2022). Many recent records were collected as part of the Pacific Northwest Bumble Bee Atlas. The Pacific Northwest Bumble Bee Atlas is a collaborative community science effort that began in 2018, involving Washington Department of Fish and Wildlife, the Idaho Department of Fish and Game, the Oregon Department of Fish and Wildlife, and the Xerces Society for Invertebrate Conservation, to track and conserve the bumble bees of Washington, Oregon, and Idaho.

Species Distribution Modeling

We modeled the range and distribution of the western bumble bee using species distribution modeling. Species distribution modeling based on maximum entropy (Maxent) methods (Maxent 3.4.1, Phillips et al. 2006, Phillips and Dudík 2008, Phillips et al. 2017, Hijmans et al. 2021) considers recorded observations of a species, as well as a variety of climatic variables (Booth et al. 2014), elevation, and land cover (Dewitz and U.S. Geological Survey 2021). We conducted all spatial analyses in ArcGIS Pro 2.8.0 (ESRI 2022) and imported relevant data into R 4.2.0 (R Core Team 2022) to manipulate data, complete Maxent species distribution modeling, and compute summary statistics.

We thinned occurrence records to counteract the impact of sampling bias and then divided them into two categories, records used to build models and records used to test models. After removing highly correlated predictor variables, we applied an iterative process to five model runs which we averaged before removing the predictor variables that least contributed to model fit. We repeated this process a total of five times. Ultimately, we selected the model with the fewest predictor variables that did not perform significantly worse than the model with all non-correlated predictors as the main species distribution model. We defined thresholds below which species distribution was considered absent for each model by selecting a threshold at which the sum of the sensitivity (the true positive rate) and specificity (the true negative rate) is highest (Hijmans et al. 2021). We modeled species distribution for both a historic (1888 through 2010) and recent (2011 through 2021) time period. Results of the species distribution models should be interpreted with caution given that the models did not include absence data (surveys in which species were not found) and the predictor variables used in the models do not represent all factors impacting bumble bee distribution.

Selection Criteria for High Priority Areas

After modeling the full distribution of the western bumble bee and cropping the distribution to the state of Washington (Figure 1), we prioritized western bumble bee conservation by county within the state. Prioritization was based on the mean probability of occupancy, with low, medium, and high priority determined using Jenks natural breaks optimization (Jenks 1967).

For the next level of specificity involved in the site assessment protocol we overlaid the species distribution model in Washington with 10 km buffers around recent observations of the species. We used 10 km buffers since this is approximately the farthest distance that bumble bees have been recorded to travel from their nest (Williams et al. 2014) and has also been used by the U.S. Fish and Wildlife Service as the scale at which bumble bee populations exist (USFWS 2020).

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Appendix 2. List of native plants and guides for plants that serve as resources for western bumble bees.

Providing wildflower-rich habitat is the most significant action you can take to support pollinators. Adult bees, butterflies, and other pollinators require nectar as their primary food source, and female bees collect pollen as food for their offspring. Native plants, which are adapted to local soils and climates, are usually the best sources of nectar and pollen for native pollinators. Incorporating native wildflowers, shrubs, and trees into any landscape promotes local biological diversity and provides shelter and food for a diversity of wildlife. Most natives require minimal irrigation, flourish without fertilizers, and are unlikely to become weedy.

The list of plant genera in the table below is listed from most- to least-visited by the species of greatest conservation need (SGCN) bumble bees in the Pacific Northwest Bumble Bee Atlas project. The list only includes plant genera appropriate for restoration projects (e.g., plant genera that do not have native species known to be attractive to bumble bees were not included). These suggestions are presented at the level of genus to allow regional selections of appropriate plant species. Listed approximate bloom times are included to help practitioners create plant lists that provide pollen and nectar resources throughout the bloom period. These bloom times will vary by species, and by habitat.

Table. Plant genera that provide key flowering resources for SGCN bumble bees in the Pacific Northwest[1].

PLANT GENUS	COMMON NAME	APPROXIMATE BLOOM TIME		
		Early	Mid	Late
Cirsium ✱	Native Thistles		■	■
Lupinus ✱	Lupine	■	■	
Trifolium	Native Clovers	■	■	
Penstemon ✱	Penstemon		■	
Agastache ✱	Horsemint	■	■	■
Ericameria	Rabbitbrush			■
Rubus	Thimbleberry	■	■	
Helianthus	Sunflower	■	■	■
Spiraea	Spiraea	■	■	■
Solidago	Goldenrod			■
Chamaenerion ✱	Fireweed		■	■
Phacelia ✱	Scorpionweed	■	■	
Rosa ✱	Rose	■	■	
Monardella	Coyote Mint		■	■
Symphoricarpos ✱	Snowberry		■	
Potentilla	Cinquefoil		■	■
Erigeron/Symphyotrichum	Fleabanes/Asters		■	■
Aquilegia	Columbine	■		
Pedicularis	Lousewort	■	■	
multi-species appeal [✱]				

[1] This table is sourced from "Hatfield, R., K. Merg, and J. Sauder. 2021b. A PNWBBA Guide to Habitat Management for Bumble Bees in the Pacific Northwest. Xerces Society, Idaho Department of Fish and Game, Washington Department of Fish and Wildlife".

Additional plant selection guides

Western Washington

Pollinator Plants: Maritime Northwest Region
https://xerces.org/publications/plant-lists/pollinator-plants-maritime-northwest-region.
This fact sheet features regionally native plants that are highly attractive to pollinators and are well-suited for small-scale plantings in gardens, urban greenspaces, and farm field borders, and on business and school campuses. In Washington, this guide is most appropriate for selecting flowering plants adapted to the westside of the state.

Eastern Washington

Partial List of Plant Species for Pollinator Habitat in the Inland Pacific Northwest
https://s3.wp.wsu.edu/uploads/sites/2061/2022/03/PPMCPlants4PollinatorsInTheInPNW.pdf
This poster, created by the USDA-NRCS Pullman Washington Plant Materials Center, lists recommended pollinator plants east of the Cascade Mountains, with detailed information on seeding rates, plant characteristics, drought tolerance, bloom time, and other attributes.

Plants for Pollinators in the Inland Northwest
https://xerces.org/pollinator-resource-center/pnw
This NRCS Technical Note provides guidance for the design and implementation of conservation plantings to enhance habitat for pollinators. Plant species included in this document are adapted to the Inland Northwest; encompassing eastern Washington, northeastern Oregon, and northern Idaho.

Appendix 3. Additional resources for pollinator habitat management.

Ecology and Conservation of Bumble Bees

Conserving Bumble Bees. Guidelines for Creating and Managing Habitat for America's Declining Pollinators.
https://www.xerces.org/publications/guidelines/conserving-bumble-bees
This thorough review of managing land for bumble bees includes sections on the important role these animals play in both agricultural and wild plant pollination, details the threats they face, and provides information on creating, restoring, and managing high-quality habitat. Importantly, these guidelines also describe how land managers can alter current practices to be more in sync with the needs and life cycle of bumble bees. This document also includes regional bumble bee identification guides and lists of important bumble bee plants by region.

A PNWBBA Guide to Habitat Management for Bumble Bees in the Pacific Northwest.
https://www.xerces.org/publications/guidelines/pnw-bb-management
Historically, an incomplete picture of the habitat needs and status of bumble bees has been a barrier to effective conservation and land management. To address this need, the Pacific Northwest Bumble Bee Atlas (PNWBBA) was launched in Idaho, Oregon, and Washington in 2018. This large-scale, three-year effort was specifically directed toward understanding bumble bee populations, their habitat needs, and the efficacy of various habitat management actions, with the goal of significantly improving the effectiveness of bumble bee conservation efforts. This document contains specific lessons learned from the PNWBBA project as well as a synthesis of our understanding of general bumble bee needs and a list of best practices for creating and managing habitat effectively for bumble bees.

Habitat Assessment

Pacific Northwest Bumble Bee Habitat Assessment Form and Guide
https://xerces.org/publications/habitat-assessment-guides/pacific-northwest-bumble-bee-habitat-assessment-form-guide
This Habitat Assessment Guide, a product of the Pacific Northwest Bumble Bee Atlas, is a tool for landowners and managers in the Pacific Northwest to score their existing habitat to highlight areas that could be enhanced, either through improved habitat management, or habitat augmentation. This tool can be used alongside our Habitat Management for Bumble Bees in the Pacific Northwest for a complete toolkit for designing and maintaining high quality bumble bee habitat in Oregon, Washington, and Idaho.

Habitat Assessment Guide for Pollinators: Yards, Gardens, and Parks
https://xerces.org/publications/habitat-assessment-guides/habitat-assessment-guide-for-pollinators-in-yards-gardens
Landscaping for pollinators is one of the easiest ways for urban, suburban, and rural residents to directly benefit local wildlife. Schoolyards, community gardens, back yards, corporate campuses, rain gardens, and neighborhood parks all have the potential to meet the most basic needs of pollinators, including protection from pesticides, and resources for foraging, nesting, and overwintering.

Habitat Assessment Guide for Pollinators: Natural Areas and Rangelands
https://xerces.org/publications/hags/pollinators-farms-and-agricultural-landscapes
This pollinator habitat assessment guide is designed for natural areas and rangelands.

Habitat Installation

Organic Site Preparation for Wildflower Establishment
https://xerces.org/publications/guidelines/organic-site-preparation-for-wildflower-establishment
Site preparation is one of the most important and often inadequately addressed components for successfully installing pollinator habitat. These guidelines provide step-by-step instructions, helpful suggestions, and regional timelines and checklists for preparing both small and large sites.

Western Oregon and Washington Conservation Cover for Pollinators
https://www.xerces.org/publications/western-oregon-washington-conservation-cover-327-for-pollinators
These region-specific guidelines provide in-depth practical guidance on how to install and maintain nectar- and pollen-rich habitat for pollinators in the form of wildflower meadow plantings/conservation cover. Seed mixes and plant recommendations are included in the appendix of each guide.

Western Oregon and Washington Hedgerow Planting for Pollinators
https://xerces.org/publications/education-resources/western-oregon-washington-hedgerow-planting-422-for-pollinators
These region-specific guidelines provide in-depth practical guidance on how to install and maintain nectar- and pollen-rich habitat for pollinators in the form of linear rows of native flowering shrubs/hedgerow plantings. Seed mixes and plant recommendations are included in the appendix of each guide.

Establishing Pollinator Meadows from Seed
https://xerces.org/publications/guidelines/establishing-pollinator-meadows-from-seed
Establishing wildflower habitat for pollinators is the single most effective course of action to conserve pollinators that can be taken by anyone at any scale. These guidelines provide step-by-step instructions for establishing pollinator meadows from seed in areas that range in size from a small backyard garden up to areas around an acre.

Habitat Management

Maintaining Diverse Stands of Wildflowers
https://xerces.org/publications/guidelines/maintaining-diverse-stands-of-wildflowers-planted-pollinators
High quality pollinator meadows sometimes experience a decline in wildflower diversity or abundance as they age. This guide provides recommendations on how to bring declining meadows back into a high quality condition.

Nesting and Overwintering Habitat for Pollinators and Other Beneficial Insects
https://xerces.org/publications/fact-sheets/nesting-overwintering-habitat
This guide focuses on a variety of natural nesting habitat features that can be readily incorporated into most landscapes. Compared to artificial nesting options such as bee blocks and bee hotels, natural nesting habitat features often better mimic the natural nest site density of insects, and also break down naturally with time, limiting disease and parasite issues.

Best Management Practices for Pollinators on Western Rangelands
https://xerces.org/publications/guidelines/best-management-practices-for-pollinators-on-western-rangelands
The Xerces Society developed these guidelines to help land managers incorporate pollinator-friendly practices into rangeland management. This publication is focused on federally managed rangelands that span the following western states: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, Oregon, Washington, and Wyoming.

Roadside Best Management Practices that Benefit Pollinators
https://xerces.org/publications/guidelines/roadside-best-management-practices-that-benefit-pollinators
These best management practices provide concrete steps that can be taken by any roadside management agency to improve roadside vegetation for pollinators. The BMPs cover management of existing habitat, including ways to modify the use of mowing and herbicides to enhance roadsides, and methods to incorporate native plants and pollinator habitat into the design of new roadsides.

Pesticide Protection

Guidance to Protect Habitat from Pesticide Contamination: Creating and Maintaining Healthy Pollinator Habitat
https://xerces.org/publications/fact-sheets/guidance-to-protect-habitat-from-pesticide-contamination
This Xerces Society guidance document was designed to help growers, land managers, and others safeguard pollinator habitat from harmful pesticide contamination. It includes information on selecting habitat sites, as well as ways to maintain clean habitat by limiting and carefully managing pesticide use.

Smarter Pest Management: Protecting Pollinators at Home
https://xerces.org/publications/fact-sheets/smarter-pest-management-protecting-pollinators-at-home
Most of North America's native bee species only forage over a distance of a few hundred yards, so with a little planning, your yard can provide a safe space for bees and other pollinators to thrive. All you need to give them are flowering plants throughout the growing season, undisturbed places to nest, and protection from pesticides. This Xerces Society guide will help you with the last item, managing yard pests in a pollinator-friendly way.

Smarter Pest Management: Pollinator Protection for Cities and Campuses
https://xerces.org/publications/fact-sheets/smarter-pest-management-pollinator-protection-cities-campuses
This Xerces Society fact sheet introduces to city and campus land managers the concept of integrated pest management, a system that emphasizes prevention first and seeks to eliminate the underlying causes of plant diseases, weeds, and insect problems rather than relying on routine use of pesticides.

Honeybees

An Overview of the Potential Impacts of Honeybees to Native Bees, Plant Communities, and Ecosystems in Wild Landscapes: Recommendations for Land Managers
https://xerces.org/publications/guidelines/overview-of-potential-impacts-of-honey-bees-to-native-bees-plant
Literature review of the potential impacts of honeybees to native bees (including bumble bees) and their habitats. It covers the potential effects of honeybees through competition with native bees and disease transmission, as well as the potential effects of honeybees on native plant populations and other wildlife.

Assistance and Incentive Programs

Bee City USA
https://beecityusa.org/
The Xerces Society's Bee City USA program provides city governments and planners with support to adopt pollinator-friendly policies and practices. Participating cities commit to follow best management practices for pollinators by adopting a resolution and reporting annually on their accomplishments.

For additional information visit the Xerces Society's Pollinator Conservation Resource Center. This webpage of pollinator conservation resources for the Pacific Northwest includes information about habitat assessment, installation, and management, selecting and sourcing native plants, and pesticide protection.

Appendix 4. Survey form for documentation of bumble bees collected in a one-hectare survey block.

Complete a new survey form for each survey block surveyed.

Survey Information

Site name:	Survey block number:	Date:	Temperature (°F):
Latitude:	Longitude – W (use decimal degrees):		Wind speed (mph):
Observer(s):		Cloud cover:	
Start time:	End time:	Survey minutes:	Total person minutes:
Primary survey method	☐ Captured all observed bumble bees	☐ Captured only bees with colors and markings similar to the western bumble bee	
Notes:			

Bumble Bee Observations

Check if Western Bumble Bee	Species:	Host plant:	Photo numbers:	Latitude (to 5 decimal places)	Longitude (to 5 decimal places)	Check if taken from a nest
☐						☐
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Appendix 5. Illustrations and photographs of western bumble bees.

Western bumble bee (female) worker, nominate color form. Although twelve color forms for females of this species have been described[1], the color form illustrated here is representative of the western bumble bee that occurs in Washington and Oregon. Both the nominate form and another color form that occurs in Washington, Oregon, and nearby areas are represented in the photographs, below. Illustration by Elaine Evans, The Xerces Society. Used with permission.

Western bumble bee from Mt. Hood National Forest, Oregon. Note the nominate color form with a black face and vertex, yellow band across the front of the thorax, and white across the rear portion of the abdomen. This color pattern, particularly the white on the thorax, is unique to this species and easily distinguishes it from other bumble bee species. Photograph by Rich Hatfield, The Xerces Society. Used with permission.

[1] Franklin, H. J. 1912. The Bombidae of the new world. Transactions of the American Entomological Society 38:177-486.

Western bumble bee, adult female. Photograph taken in Johnson's Landing, British Columbia. Photo by Gail Spitler.

Western bumble bee, adult male. Photograph taken on the Wallowa-Whitman National Forest. Photo by the Xerces Society/Rich Hatfield.

Appendix 6. The following habitat assessment guide is adapted from Xerces' Pacific Northwest Bumble Bee Habitat Assessment Form and Guide (Xerces 2018).

Instructions:
Below are measurements for assessing the habitat for western bumble bee on a parcel. The completed assessment should cover the entire parcel(s) where the development or activity is being proposed. Most measurements in this survey can be collected on a single site visit. However, measurements for foraging habitat are best done on three separate dates. For the Foraging Habitat section in the assessment (Section 3), survey for "3b", "3c", and "3d" in the spring, summer, and fall, respectively. Select the multiple-choice that best applies to the parcel you are assessing for each question. Then sum up the total scores in the table at the end of the survey form. Include with your habitat management plan a copy of the completed habitat assessment forms. As part of the habitat assessment, identify on a map any areas largely void of floral resources. Do this mapping during each of three seasonal visits to the parcel(s). Create a map showing where these places are. Make sure that the GIS coverage shows which areas are lacking plants in flower during the spring, then summer, and then again in the fall. Using GIS in the office, identify these locations by season and use that to identify locations on the parcel that are largely lacking floral resources year-round.

Site Summary

Owner/ Operator:		Planner:
Survey locality/address:		
Dates	Existing condition assessment:	
	Assessment after implementation:	
Define and describe the project area (attach annotated maps; include Ecological Classification System information, if known):		

Total Score for Habitat Assessment

The figures entered into this summary table will be calculated during completion of the assessment.

	BEFORE	AFTER
Section 1: Regional and Landscape Features *(max score 20)*		
Section 2: Site Features *(max score 35)*		
Section 3: Foraging Habitat *(max score 50)*		
Section 4: Nesting and Overwintering Habitat *(max score 30)*		
Section 5: Management and pesticide Practices *(max score 25)*		
OVERALL SCORE		

Section 1: Regional and Landscape Features

The characteristics of regional and landscape features have a significant impact on bumble bees and their ability to successfully find a mate and reproduce. The landscape characteristics at this scale may not be changeable, but will help determine the scale at which local habitat management matters.

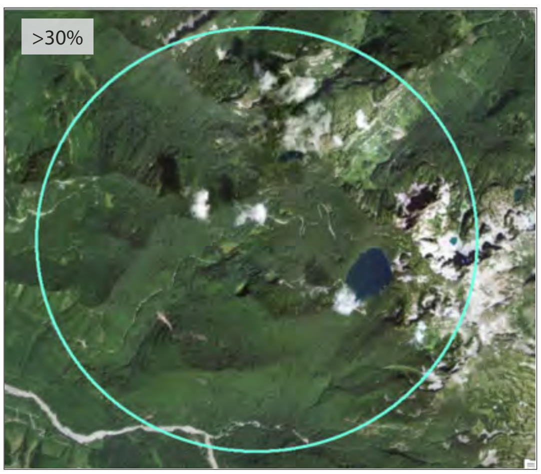
1a. Percentage of the surrounding area that is natural habitat. This land use cover includes prairie, shrub lands, woodlands, grasslands, riparian habitat, wetlands, and non-invasive weedy areas. It does NOT include lawn grass, cropland, or overgrazed pasture. Using an area within a 5 km radius of your location, analyze the proportion of the habitat that is natural. See photos below for guidance (blue circle has a radius of 5 km).

Max score of 10.

SELECT ONLY ONE	Score	Existing Condition
>30%	10	
20%–30%	7	
5%–20%	3	
<5%	0	
Subtotal (1a)		

(1a)

The photos below illustrate the different percent covers.



Continue on next page

Continue here

Section 1: Regional and Landscape Features *continued*

1b. The assessment area is defined by the unit of land on which management can be implemented to improve habitat for bumble bees. With that in mind, what is the dominant vegetation within ½ mile of assessment area including the assessment area itself. *Max score of 10.*

SELECT ONLY ONE	Score	Before	After	Treatment to increase score (no treatment if off-site)
Native plants	10			
Mix of native and naturalized (non-invasive) plants	7			
Naturalized flowering species (e.g., alfalfa)	5			
Mix of native, naturalized, and weedy/invasive species	3			
Invasive flowering weeds, crops and/or sod-forming grasses	0			
Subtotal (1b)				(1b)
Regional and Landscape Features Total				(1a + 1b)

(1a)

Section 2: Site Features

On-site natural areas and other features have a significant influence on bumble bee abundance and diversity.

2a. Percentage of site that is in natural or semi-natural habitat.

Max score of 10.

SELECT ONLY ONE	Score	Before	After	Treatment to increase score
>75%	10			
50%–75%	7			
25%–49%	5			
10%–24%	3			
<10%	0			
Subtotal (2a)				(2a)

2b. Additional site features that are present.

Max score of 25.

SCORE ALL OPTIONS THAT APPLY	Score	Before	After	Treatment to increase score
Permanent meadows or open areas with diverse native wildflowers allowed to bloom	10			
Pasture or hayed land with >30% non-invasive, bee-friendly forage legumes (e.g., red clover, alfalfa, etc.) allowed to bloom	5			
Wooded or wetland areas with diverse flowering trees, shrubs, and/or wildflowers (e.g., maples, basswood, willows, wild plum, spring blooming woodland ephemerals)	5			
Buffers: 2 points for every 20% of area within 25' of water features that is flowered, 1 point for every 20% of area that is grass, 0 points for no buffers	0–5			
Subtotal (2b)				(2b)
Site Features Total				(2a + 2b)

Section 2: Site Features

Section 3: Foraging Habitat

High flower abundance and season long bloom positively influence bee abundance and diversity.

3a. Percentage of vegetative cover that is comprised of forbs, flowering shrubs, or pollinator-friendly trees on site. *This does not include invasive or noxious species (e.g., Canada thistle, spotted knapweed, purple loosestrife, Himalayan blackberry, Scotch broom, tansy ragwort, yellow starthistle, etc.). Max score of 10.*

SELECT ONLY ONE	Score	Before	After	Treatment to increase score
>50% cover	10			
30%–50% cover	7			
20%–30% cover	5			
10%–20% cover	3			
<10% cover	1			
Subtotal (3a)				(3a)

The photos below illustrate some categories. See page 12 for lists of preferred pollinator plants and other information.

Continue on next page

Section 3: Foraging Habitat

Continue here

Section 3: Foraging Habitat *continued*

Section 3: Foraging Habitat

3b. Number of species of forbs, flowering shrubs, or pollinator-friendly trees on site that bloom in **spring** and support bees. *This includes fruit trees and some flowering weeds like dandelions, but does not include invasive or noxious species (see https://plants.usda.gov/java/noxiousDriver for examples).*

Max score of 10.

SELECT ONLY ONE	Score	Before	After	Treatment to increase score
10+ species	10			
5–9 species	5			
1–4 species	3			
0 species	0			
Subtotal (3b)				(3b)

(3a)

3c. Number of species of forbs, flowering shrubs, or pollinator-friendly trees on site that bloom in **summer** and support bees. *This includes some flowering non-native plants, such as red clover, but does not include invasive or noxious species (see https://plants.usda.gov/java/noxiousDriver for examples).*

Max score of 10.

SELECT ONLY ONE	Score	Before	After	Treatment to increase score
18+ species	10			
10–17 species	7			
1–9 species	3			
0 species	0			
Subtotal (3c)				(3c)

3d. Number of species of forbs, flowering shrubs, or pollinator-friendly trees on site that bloom in **fall** and support bees. *This includes some flowering non-native plants, such as red clover, but does not include invasive or noxious species (see https://plants.usda.gov/java/noxiousDriver for examples).*

Max score of 10.

SELECT ONLY ONE	Score	Before	After	Treatment to increase score
10+ species	10			
5–9 species	7			
1–4 species	5			
0 species	0			
Subtotal (3d)				(3d)

Continue on next page

Continue here

Section 3: Foraging Habitat *continued*

Section 3: Foraging Habitat

3e. Bumble bee superfoods. Pacific Northwest bumble bees prefer the following plants. How many of these plants are present on site? Note that some of these species may not be appropriate for every region/site.

Aster and daisys (*Aster* spp., *Bellis* spp., etc.), rabbitbrush (*Chrysothamnus* spp.), milkvetch (*Astragalus* spp.), sunflower (*Helianthus* spp.), wild bergamot (*Monarda fistulosa*), currant (*Ribes* spp.), spiraea (*Spiraea* spp.), goldenrod (*Solidago* spp.), phacelia (*Phacelia* spp.), thistles (*Cirsium* spp.), milkweed (*Asclepias* spp.), white prairie clover (*Dalea candida*), sweetclover (*Melilotus alba*)

Max score of 7.

SELECT ONLY ONE (how many species of bumble bee superfoods are present on site?)	Score	Before	After	Treatment
9–13 species	7			
5–8 species	5			
1–4 species	2			
0 species	0			
Subtotal (3e)				(3e) →

3f. In addition to plants that are known to be attractive to bumble bees, the following plants are known to help build bumble bee immune systems. How many of these plants are present on site? Note that some of these species may not be appropriate for every region/site.

Sunflowers (*Helianthus* spp.), penstemon or beardstongue (*Penstemon* spp.), plantain (*Plantago* spp.), wild blueberry/ cranberry (*Vaccinium* sp.), and wild tobacco (*Nicotiana* spp.).

Max score of 3.

SCORE THIS OPTION	Score	Before	After	Treatment
Score 1 point, up to 3 for each species present	0–3			
Subtotal (3f)				(3f) →

(3a-d)

Foraging Habitat Total ← (3a + 3b + 3c + 3d + 3e + 3f)

Section 4: Nesting and Overwintering Habitat

Bumble bee colony success is often limited by the availability of suitable nesting and overwintering sites. Diverse habitat features will increase the likelihood of nesting and overwintering success.

4. Bumble bee nesting preferences vary by species and local habitat conditions. Generally, bumble bees nest under ground, often in abandoned rodent nests. They are also known to nest in dry cavities above ground, such as in rock walls or under clump-forming bunch grasses. The nests are often found under woody plants, tall grasses, or hidden among vegetation or plant materials, and can be difficult to detect. Bumble bees often overwinter underneath leaf litter, in the duff layer of forests, or under loose soils.

Max score of 30.

SCORE ALL OPTIONS THAT APPLY	Score	Before	After	Treatment to increase score
Areas of undisturbed (for example, ungrazed) native bunch grasses (clump-forming)	>20% = 5 ~20% = 3 <5% = 1			
Areas with loose soil with evidence of rodent activity (holes, surface tunnels, etc.) (compacted or hard packed bare ground does not count toward the total)	>20% = 5 ~20% = 3 <5% = 1			
1 point for every 10% of area that is unmowed, ungrazed, and not subject to controlled burning	0–10			
Areas of site with woody cover, or other sheltered areas where bumble bees could build their nest or overwinter (downed wood, rock walls, brush piles, forest duff layer, etc.)	>20% = 5 ~20% = 3 <5% = 1			
Leaf litter left on site in the fall and through the spring (for overwintering queens)	5			
Nesting and Overwintering Habitat Total				

The photos below illustrate some typical nesting and overwintering habitat.


a


b


c


d

Section 5. Management Practices

Management practices in and around habitat areas have a significant influence on bee populations.

5a. Are land management techniques used in the area beneficial to pollinators?
Max score of 15.

Grazing (Select only one)	Score	Before	After	Treatment to increase score (no treatment if off-site)
The site will not be grazed.	5			
This site will be grazed with a conservation grazing plan in place and includes prescribed grazing practices to encourage wildflower diversity/abundance, (e.g., low intensity grazing, or short duration grazing with long recovery periods).	2			
Conventional grazing practices will happen on the site.	0			
Subtotal (*grazing*)				

Burning (Select only one)	Score	Before	After	Treatment to increase score (no treatment if off-site)
The site will not be burned or burned specifically to enhance floral resources.	5			
If burning is not carried out to encourage floral resources, then entire disturbed area is limited to 1⁄3 of habitat per year, and a patchy burn approach is used, leaving numerous skips and unburned patches. A 3 to 10 year burn rotation period is used, and the time of year when burning occurs is varied. Rare invertebrate species and their specific needs are considered.	2			
Burning will occur on more than a 1/3 of the parcel in a given year.	0			
Subtotal (*burning*)				

Mowing / haying (Select only one)	Score	Before	After	Treatment to increase score (no treatment if off-site)
The site will not be mowed or hayed.	5			
If mowing/haying occurs, then entire disturbed area is limited to 1⁄3 of habitat per year. Haying or mowing is done patchily, at reduced speeds (<8 mph), with high mower height (12–16"), and in late summer (after peak bloom).	2			
Habitat will be mowed/hayed with conventional practices.	0			
Subtotal (*mowing / haying*)				
Total (Grazing + Burning + Mowing / Haying)				(5a)

Section 5. Management Practices

Management practices in and around habitat areas have a significant influence on bee populations.

(5a)

5b. Is the area protected from pesticide use, including herbicides that result in loss of flowering plants as well as pollinator-toxic insecticides?

Max score of 10.

Site features Score all options that apply	Score	Before	After	Treatment to increase score (no treatment if off-site)
No use of herbicides or insecticides on site.	10			
Buffer of at least 30 feet between any herbicide or insecticide application and habitat areas, either on- or off-site.	2			
Invasive weed control, if any, carried out with targeted herbicide applications, rather than broadcast.	1			
If insecticides are used, spray drift is carefully controlled.	1			
If insecticides are used, spray equipment calibrated annually, as per state regulations	1			
Subtotal (5b)				(5b)
Management Practices Total				(5a + 5b)

Appendix 7. Habitat management plan template.

<table>
<tr><td>Applicant's Full Name</td><td>Applicant's mailing address:</td></tr>
<tr><td>Plan prepared by:
(Full name and company affiliation)</td><td>Date submitted:</td></tr>
<tr><td>County</td><td>Parcel ID number(s) of proposed development site.</td></tr>
<tr><td colspan="2">Description of the proposed project:</td></tr>
<tr><td colspan="2">Western bumble bee site survey:

Please describe below the procedure used to survey for western bumble bees on the parcel(s).

Attachments with the HMP:
• Copies of the completed observation forms (Appendix 4).
• Map of the site to scale clearly showing points to identify where each individual western bumble bee was collected. On the map should also be the location of grid cells surveyed (with ID # for each cell clearly marked).
• GIS layer of the western bumble bee point data.</td></tr>
<tr><td colspan="2">Habitat Assessment:

Complete the habitat assessment found in Appendix 6.

Attached with the HMP:
• Fully completed habitat assessment form, including the table at the end showing the scores for each section in the assessment as well as the total score for the parcel(s)
• Map of the entire parcel showing an overlap of the GIS layers (areas void of plants in flower) for spring, summer, and fall, as well as another map showing any areas void of flowers year-round.
• GIS layer of the areas lacking plants in flower by season and overall.</td></tr>
</table>

Description of resources on the parcel: **Instructions**: Please include with the habitat management plan a description of what resources (for western bumble bee) you found on the parcel(s) and where they are located within the parcel(s). The description should be based on the results of the bumble bee survey, habitat assessment, as well as the map showing locations lacking floral resources. Include here a map showing where resources occur on the parcel as well as any areas that seem to be lacking resources altogether. Resources include any locations where there was a western bumble bee observation or areas where there were floral resources during at least one season. Areas where there is a relatively dense concentration of flowers, wide varieties of plant species in flower, areas in flower year-round (spring through fall), or where nests are found are likely important to bumble bees, including western bumble bee. Make sure to map and describe any locations on the parcel that fit these characteristics of important bumble bee habitat.
Mitigation sequencing: **Instructions**: Include a description of reasonable efforts made to apply mitigation sequencing. Mitigation sequencing, to avoid, minimize, and compensate impacts to critical areas.
Mitigation: **Instructions**: Describe here the plan you intend to implement to ensure no-net-loss of habitat features important to western bumble bees on the parcel(s). Create a plan that includes adequate detail so that any reader will clearly understand the steps that will be taken, their precise mapped locations on the parcel, and their timing. Describe how these steps will ensure that no-net-loss of habitat function is achieved on the site, and if the site is being developed or undergoing any land use action, how the measures will fully offset the loss of function that may be caused by the land use activity. Also, include a description of the process that will be implemented to monitor the mitigation measures to ensure their success over the long-term.
Financial guarantees: Please describe in detail the financial guarantees to ensure compliance with the measures described in the mitigation section, such as a performance bond describing the dollar amount, terms in which claims can be made against the bond, as well as the time period that the bond will be in effect.

Glossary

Adaptive management - Adaptive management involves implementing a management strategy, closely monitoring its effects and then adapting future actions based on the observed results. In this way, planners simultaneously apply management practices and learn from those management practices.

Buzz pollination - A process that involves the vibration of flight muscles at the correct frequency to release pollen. This ability makes bumble bees the most effective pollinators of certain families of plants (particularly those with poricidal anthers).

Corolla - The petals of a flower. In some species, flower petals can be completely separate, creating a flat, open flower while in other species the petals are fused, forming a long, tubular shape.

Diapause - Periods of arrest in the development of insects and other organisms, similar to hibernation.

Flight period - The period between when queens first emerge from overwintering in the spring and when they enter overwintering sites in the fall. Also referred to as the active period.

Forb - An herbaceous, or non-woody, flowering plant that is not a grass, sedge, or rush.

Generalist forager - A species that visits a wide range of plants to collect resources (nectar and pollen). The term 'generalist' can also be applied to other habitat requirements including nesting.

Habitat connectivity - The degree to which the landscape facilitates or impedes movement among resource patches. Can be important for maintaining ecological, population-level, or evolutionary processes.

Nectar robbing - A behavior in which bees chew a hole in the base of flowers with long corollas to obtain nectar without facilitating plant pollination.

Net Ecological Gain - A standard for a development project or activity in which the impacts on the ecological integrity caused by the development are outweighed by measures taken to avoid, minimize, or compensate for any remaining impacts in an amount sufficient for the gain to exceed the loss.

Pathogen spillover - The transmission of a pathogen from a reservoir population to a host population.

Senesce - Deteriorate with age.

Systemic pesticides - Pesticides absorbed by and transported through plants. These chemicals can render some or all of a plant toxic to insects that feed on plant tissue. Systemic insecticides include neonicotinoids, which have been widely recognized for their risk, in part because they are far more toxic to bees than most other insecticides and are also very persistent.