Strategy to Protect State and Federally Recognized Bumble Bee Species of Conservation Concern

Washington State

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Developed through a partnership between the Xerces Society, the Forest Service, the Bureau of Land Management, Washington Department of Fish and Wildlife, and the US Fish and Wildlife Service

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Cover Photo

Bombus kirbiellus on *castilleja* sp. in north central Washington. Photo by the Xerces Society/Rich Hatfield.

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Accompanying Materials

We developed an interactive online map that allows users to view information in unique combinations and at varying scales, customized to their needs. This map allows information to be displayed, including potential threats and land cover, at a finer scale than is included in the current strategy. This map can be accessed at: https://xerces.org/publications/strategy-bumble-bee-species-conservation-concern.

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DISCLAIMER

This conservation strategy was prepared to compile published and unpublished information on eight species of bumble bee: *Bombus frigidus* (frigid bumble bee), *B. kirbiellus* (golden-belted bumble bee), *B. morrisoni* (Morrison bumble bee), *B. occidentalis* (western bumble bee), *B. suckleyi* (Suckley cuckoo bumble bee), *B. vagans* (half-black bumble bee), *B. fervidus* (yellow bumble bee), and *B. pensylvanicus* (American bumble bee). Although the best scientific information available was used and subject experts were consulted in preparation of this document, it is expected that new information will arise. If you have information that will assist in conserving these species or questions concerning this Conservation Strategy, please contact the interagency Conservation Planning Coordinator for Region 6 of the U.S. Forest Service, and the Oregon/Washington Bureau of Land Management (BLM OR/WA). While this document includes recommendations for management actions to support the conservation of rare bumble bees, this does not constitute direction or obligations to state or federal agencies.

EXECUTIVE SUMMARY

Purpose of Statewide Bumble Bee Conservation Strategy

The objective of this conservation strategy is to identify geographic areas within the state of Washington with the highest potential to support rare and declining bumble bee species and provide guidance and recommendations for management of those areas. Maintaining sufficient populations of each focal species is essential to the long-term persistence of these animals. This will require protecting and enhancing habitat for foraging, nesting, and overwintering, while ensuring connectivity between habitat areas, across jurisdictions. While this conservation strategy focuses primarily on lands managed by federal and state agencies, conservation actions taken on privately owned property will increase the likelihood of species persistence, and may reduce the need for additional regulatory protections.

Species

This conservation strategy focuses on the following focal species and their conservation in the state of Washington: *B. frigidus* (frigid bumble bee), *B. kirbiellus* (golden-belted bumble bee), *B. morrisoni* (Morrison bumble bee), *B. occidentalis* (western bumble bee), *B. suckleyi* (Suckley cuckoo bumble bee), *B. vagans* (half-black bumble bee), *B. fervidus* (yellow bumble bee), and *B. pensylvanicus* (American bumble bee). While not included in the selection of high priority areas for conservation, other bumble bee species and pollinators more generally will benefit from the management recommendations included in this strategy.

Methods

We completed a variety of analyses in order to translate available information about bumble bee species and geographic, environmental, and anthropogenic factors into actionable conservation recommendations. To inform this process, we modeled species distribution (historic, recent, and trend) for all eight focal species. We sourced occurrence records of the eight focal bumble bee species from a database of more than 700,000 records of 43 species of North American bumble bees compiled from various collections, research projects, and other datasets (Richardson 2022). Once the species distribution models (SDMs) were complete, we used the aggregate mean of all eight species' modeled recent distributions (the predicted probability of presence) to rank EPA level IV ecoregions by conservation priority, with high priority areas having the highest mean value within the area. To ensure that areas around known recent occurrences of focal species were explicitly incorporated in conservation opportunities, we mapped 10 km buffers around known recent occurrences for all eight focal species. We address ecoregions with a high number of focal species occurrence records, but low priority ranking based on SDMs, for all species separately.

Next, we developed a threat matrix and analyzed those threats spatially in order to understand potential threats and their impacts across ecoregions identified as priorities for the conservation of the eight focal bumble bee species. In order to provide additional information to enable land owners and land managers to identify focal areas for conservation efforts, we analyzed the overlap of predicted potential geographic distribution, priority areas, and occurrence records with property ownership and management. This information allows land owners and managers to consider the overlap between existing management projects and priority areas for bumble bee conservation. Finally, we assessed the primary land cover (or covers) within each priority ecoregion. We provide management recommendations by land cover class. We also provide general management recommendations and best management practices to mitigate potential threats.

Priority Management Areas

Washington's 57 level IV ecoregions (Figure 4) are evenly split across priority levels (19 in each category); high, medium (Table 2), and low (Table B 10) (Figure 1). Ecoregions were divided into classes using Jenks natural breaks optimization (Jenks 1967), and the even distribution of ecoregions between categories is incidental. The high priority ecoregions are generally distributed in a horseshoe shape around the Columbia Plateau; from the Yakima Plateau and Slopes in the southwest; north along the eastern foothills of the North Cascades to the Okanogan Pine/Fir Hills, Okanogan Valley, and Western Okanogan Semiarid Foothills; east to the Selkirk Mountains; and south through the Palouse Hills. Medium priority ecoregions generally surround the high priority ecoregions with the exception of a band of medium priority ecoregions from the Portland/Vancouver Basin, north through the Puget Lowlands to the Fraser Lowlands. ***While this document focuses on recommendations to reduce threats in high and medium priority ecoregions, equal effort needs to be focused on maintaining high quality habitat where it already exists (e.g., higher elevations of the Cascades), regardless of ecoregion priority.***

The majority of occurrence records fall within the horseshoe of medium and high priority ecoregions around the Columbia Plateau and in the Puget Lowlands area. However, some clusters of recent occurrence records fall outside of ecoregions identified as medium or high priority in our analysis (Figure 5). These ecoregions are generally occupied by only a few species rather than a higher number of species, as is often the case for the medium and high priority ecoregions. ***We recommend taking steps to conserve imperiled bumble bees in areas within 10 km of recent occurrence records regardless of the priority of the ecoregion where they are located.***

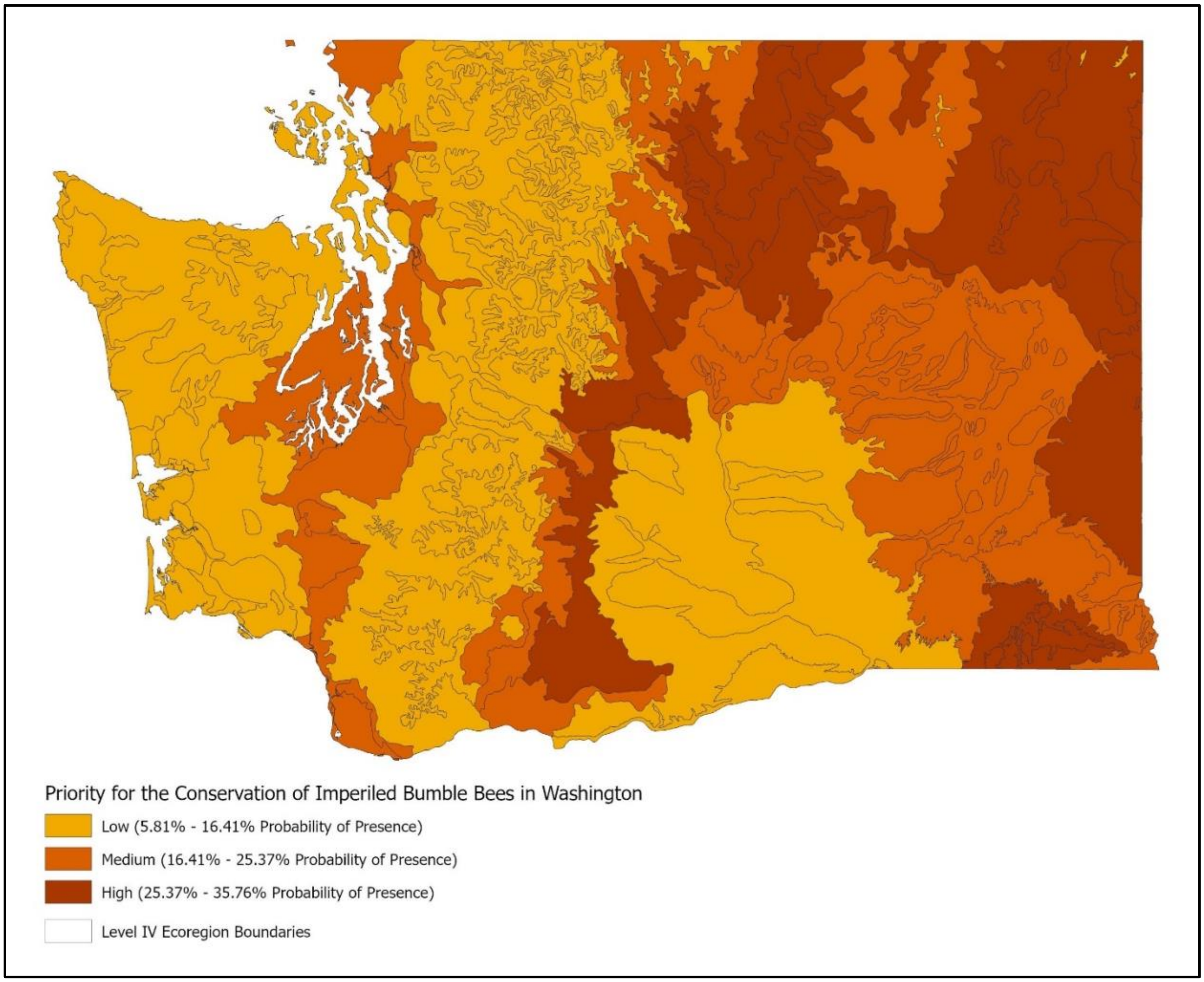


Figure 1. Mean probability of presence for all focal species based on modeled species distribution during the recent (2011 - 2021) time period. Ecoregions in red indicate the highest priority for conserving imperiled bumble bees, ecoregions in orange indicate medium priority, and ecoregions in yellow indicate low priority.

Management Recommendations

This conservation strategy includes information and resources for land managers to implement effective actions to conserve eight focal bumble bee species within high priority areas. We provide a framework for integrating potential threats, existing land cover, and ownership/management status into management to benefit these species at a range of scales, from state-wide scale long-range planning to site scale planning. The primary goal of our management recommendations and best management practices is to support bumble bees by providing the habitat they rely on for foraging, nesting, and overwintering, and protecting that habitat from threats.

Adaptive Management

The information included in this conservation strategy represents our understanding of the focal species, their status, factors impacting them, and recommended conservation actions at the time when the strategy was written. As more data is collected on these species, recommended conservation strategies may change, based on current conditions and knowledge. Likewise, the suite of species included on state and federal lists of conservation need may change. This may also change the priority actions and locations described here.

Potential Threats and Forces Shaping Ecosystems

Bumble bees face a variety of potential threats including exposure to pathogens and competition from managed bumble bees and honey bees, impacts from reduced genetic diversity, habitat alterations including conifer encroachment, grazing, logging, exposure to pesticides, fire, agricultural intensification, urban development, and climate change. While these factors often negatively impact bumble bees, when managed appropriately some of these land use practices have the potential to benefit bumble bees. Understanding the relative impact of these factors across species' ranges, while identifying priority areas for conservation, informs on-the-ground management appropriate to regional conditions and stressors.

To build this conservation strategy, we analyzed potential threats for which adequate, high quality data is available. The aggregate, or mean, threat posed by agriculture and development, grazing, wildfire, pesticides, and climate change is highest on the eastern slope of the Cascades, overlapping with ecoregions designated as high priority for conservation (Figure 1, Figure 19, Table 2, Table 5). This includes the Yakima Plateau and Slopes, Grand Fir Mixed Forest, Okanogan Pine/Fir Hills, and Okanogan Valley ecoregions. The majority of other medium and high priority ecoregions fell into the medium threat category. Details on the threat posed by each of these factors individually is provided in the section on potential threats.

Research, Inventory, and Monitoring Opportunities

While research into bumble bee distribution, habitat associations, and nesting and overwintering habits has increased in recent years, many gaps still remain in our understanding of these species. Gathering data on occurrences, including foraging, nesting, and overwintering individuals, and habitat associated with those occurrences, is essential to expanding our understanding of these species, potential threats driving population trends and species distribution, and management strategies to protect existing populations and expand suitable habitat.

INTRODUCTION

Goal

The goal of this conservation strategy is to identify priority areas for conservation, to assess threats, and to recommend actions for the conservation and recovery of eight bumble bee species of conservation concern in the state of Washington. The intended users of this strategy are both public land managers and private landowners who seek input regarding how and where to incorporate considerations for imperiled pollinator species into habitat planning and management – whether that be on a national forest, wildlife refuge, BLM district, state wildlife area, or one's own property.

Scope

This conservation strategy focuses on the following species and their conservation in the state of Washington: frigid bumble bee (*B. frigidus*)*,* golden-belted bumble bee (*B. kirbiellus*)*,* Morrison bumble bee (*B. morrisoni*)*,* western bumble bee (*B. occidentalis*)*,* Suckley cuckoo bumble bee (*B. suckleyi*)*,* half-black bumble bee (*B. vagans*)*,* yellow bumble bee (*B. fervidus*)*,* and American bumble bee (*B. pensylvanicus*). Although not included in the selection of high priority areas for conservation, other bumble bee species and pollinators more generally will benefit from the management recommendations included in this strategy. While the strategy includes information on the status, threats, and potential conservation actions across all jurisdictions, the strategy was developed in partnership with the US Forest Service (USFS), Bureau of Land Management (BLM), Washington Department of Fish and Wildlife (WDFW), and US Fish and Wildlife Service (FWS), with a focus on opportunity areas within lands managed by these agencies.

Bumble Bee Conservation Status

Bumble bees (*Bombus spp.*, Apidae) are important pollinators throughout much of the world, particularly in the Northern Hemisphere. Their long tongues and ability to fly in inclement weather makes them essential as pollinators of many plant families in wildlands and natural areas, as well as significant contributors to the global agricultural industry. Unfortunately, there have been alarming reports of bumble bee population declines from North America, as well as other continents.

More than one-quarter of all North American bumble bees face extinction risk (Hatfield et al. 2015), and multiple species of bumble bees have been considered for listing as endangered species under the US Endangered Species Act (ESA). In the Western United States, the western bumble bee, Suckley cuckoo bumble bee, and American bumble bee are all currently under review for ESA listing by the US Fish and Wildlife Service (USFWS 2022). Both Franklin's bumble bee, which occurs in southern Oregon and Northern California, and the rusty patched bumble bee, which occurs in the Upper Midwest and along the eastern seaboard, have been listed as Endangered Species. Several North American species have been recently added to State Wildlife Action Plans (SWAPs) as Species of Greatest Conservation Need (SGCN). Washington's SWAP includes the western, Morrison, and Suckley cuckoo bumble bees. The USFS and BLM list the Morrison bumble bee as a sensitive species in Oregon and the western and Suckley cuckoo bumble bees as sensitive species in Oregon and Washington (USDA Forest Service and Bureau of Land Management 2019). An assessment by the Xerces Society, in collaboration with the International Union for Conservation of Nature (IUCN) Bumble Bee Specialist Group, determined the Suckley cuckoo bumble bee as Critically Endangered and the yellow, Morrison, western, and American bumble bees as Vulnerable (Hatfield et al. 2015). While not currently considered species of particular concern across their ranges, the frigid, golden-belted, and half-black bumble bees are considered of conservation concern in Washington because while their range overlap in the state of Washington is minimal they may be at risk of future declines. As such, these species are included in this conservation strategy.

Table 1. Conservation status of focal bumble bee species.

Species Scientific Name	Species Common Name	Global Status *1	United States National Status *1	WA State Status *1	Federal Status *1, *2	IUCN Red List
Bombus fervidus	yellow bumble bee	**G3G4** (last reviewed 07 April 2018)	**N4?**	**S4?**	**Not listed**	**Vulnerable** (Last reviewed 19 August 2014) *4
Bombus frigidus	frigid bumble bee	**G5** (last reviewed 26 December 2020)	**N4?**	**S2?**	**USFWS: Not Listed, USFS and BLM: WA Sensitive**	**Least Concern** (last reviewed 21 August 2014) *3
Bombus kirbiellus	golden-belted bumble bee, mountain bumble bee, high country bumble bee	**G3G5** (last reviewed 07 April 2018)	**N5**	**S1?**	**USFWS: Not Listed, USFS and BLM: WA Sensitive**	**Data Deficient** *
Bombus morrisoni	Morrison bumble bee	**G3** (last reviewed 07 April 2018)	**N3**	**S4?**	**USFWS: Not Listed, USFS and BLM: OR Sensitive**	**Vulnerable** (last reviewed 21 August 2014) *3
Bombus occidentalis	western bumble bee	**G3** (last reviewed 08 April 2018)	**NNR**	**S2S3**	**USFWS: Under Review** (positive 90 day finding March 2016), **USFS and BLM: WA and OR Sensitive**	**Vulnerable** (last reviewed 29 December 2014) *4
Bombus pensylvanicus	American bumble bee	**G3G4** (last reviewed 08 April 2018)	**NU**	**None**	**USFWS: Under Review** (positive 90 day finding September 2021)	**Vulnerable** (last reviewed 19 August 2014) *4

Species Scientific Name	**Species Common Name**	**Global Status** *[1]	**United States National Status** *[1]	**WA State Status** *[1]	**Federal Status** *[1], *[2]	**IUCN Red List**
Bombus suckleyi	Suckley cuckoo bumble bee	**G2G3** (last reviewed 08 April 2019)	**NU**	**S1?**	**USFWS: Under Review, USFS and BLM: WA and OR Sensitive**	**Critically Endangered** (last reviewed 19 August 2014) *[4]
Bombus vagans	half-black bumble bee	**G4** (last reviewed 07 April 2018)	**N4?**	**S2?**	**USFWS: Not listed, USFS and BLM: WA and OR Sensitive**	**Least Concern** (last reviewed 19 August 2014) *[4]

*[1] (NatureServe 2022)
*[2] (USFWS 2022)
*[3] (Hatfield et al. 2014)
*[4] (Hatfield et al. 2015)
*[5] (Hatfield et al. 2016)

AN INTRODUCTION TO BUMBLE BEES: BIOLOGY AND ECOLOGY

Life History

Of the nearly 20,000 species of bee worldwide, about 250 belong to the genus *Bombus* (Williams et al. 2014). Bumble bees occur throughout much of the world, providing important ecosystem services by pollinating wild and cultivated plants. Around fifty bumble bee species are found in North America, with the highest diversity in western mountain ranges. While bumble bee diversity is highest in temperate and montane climates, bumble bees are found in a range of environments including prairies, desert uplands, savannas, gardens, wetlands, and agricultural landscapes. Bumble bees are particularly important pollinators in a variety of ecosystems as they visit a wide range of plants to collect resources (nectar and pollen), can survive in cold climates and fly in inclement weather, and "buzz" pollinate, a process involving the vibration of flight muscles to release pollen from flowers with poricidal anthers.

Bumble bees are primarily eusocial, living in colonies of related individuals that cooperate to support the colony by collectively foraging for food, rearing offspring, and defending the nest. This eusocial lifestyle is an essential component of determining the suitability of foraging, nesting, and overwintering habitat.

Bumble bees have an annual life cycle. Generally, in the early spring, a queen bumble bee (gyne) initiates a new colony by selecting a nest site, building a waxen structure, and then collecting resources (pollen and nectar) to support her offspring. The solitary queen lays eggs within the nest and continues to provision the nest and incubate larvae until the first brood of female workers has emerged as adults. Like other insects in the order Hymenoptera, bumble bees undergo complete metamorphosis between larval and adult stages. This first brood are almost always female workers. Once these first larvae have metamorphosed from larvae to adults they take over foraging, feeding developing larvae, and defending the colony while the queen continues to lay eggs and tend to her developing larvae. Average bumble bee colony size ranges from 100 to 400 workers, although there are species with exceptionally large colony sizes (>1,000), and exceptionally small colony sizes (<50) (Goulson 2010). While colony size has not been well documented for many species, western bumble bee colonies containing up to 1,685 workers and producing up to 360 new queens have been documented (Macfarlane et al. 1994). In the fall, eggs develop into reproductive individuals—new queens and males. Males leave the nest in search of a mate, and new queens continue to return to the nest while they forage for resources to build fat reserves to survive the winter, and search for a mate. Once mated, the new queens find suitable locations (hibernacula) to overwinter. These queens store sperm through the winter until they initiate a colony the following spring. Sex determination in bumble bees, and all other bees, is controlled by a genetic system called haplodiploidy. Haploid eggs, or unfertilized eggs, develop into females while diploid eggs, or fertilized eggs, develop into males. Following mating in the fall, female bees store sperm throughout the winter, releasing it as needed to determine the sex of her offspring.

While most bumble bees are social, cuckoo bumble bees in the subgenus *Psithyrus* have evolved a different strategy where they enter the nest of a social species, sometimes killing the queen, and force the workers to rear their young. Because they lack a mechanism to carry pollen, cuckoo bumble bees are dependent on social bumble bees to collect pollen on which to rear their young (Goulson 2010). All members of the species have equal status and are reproductive. There is no division of labor within *Psithyrus* species. Cuckoo bumble bees typically emerge from their hibernacula later in the spring than other bumble bee species. This ensures that adequate hosts have an established nest before the female cuckoo emerges. Cuckoo bumble bees often attack a broad range of host species, but some species specialize on a single species or subgenus. The Suckley cuckoo bumble bee has been observed breeding in nests of the western bumble bee, and has been recorded as present in the colonies of yellow-banded (*B. terricola*), red-belted (*B. rufocinctus*), yellow, Nevada (*B. nevadensis*), and white-shouldered (*B. appositus*) bumble bees (Thorp et al. 1983, Williams et al. 2014).

Activity Patterns and Movements

Bumble bees' activity and behavior patterns vary throughout the year as they move through a range of life stages (Figure 2). Active periods, during which individuals are actively nest searching, foraging, or mating, depend on a variety of factors including species, latitude, elevation, annual climate variability, and ecosystem characteristics. In North America, the active period for bumble bees generally begins with colony initiation by queens sometime between early February and mid-April and ends between late September and late November (Williams et al. 2014), when all colony members die except the newly mated queens. The peak of colony activity in Washington varies by species, but generally occurs between late June and early August.

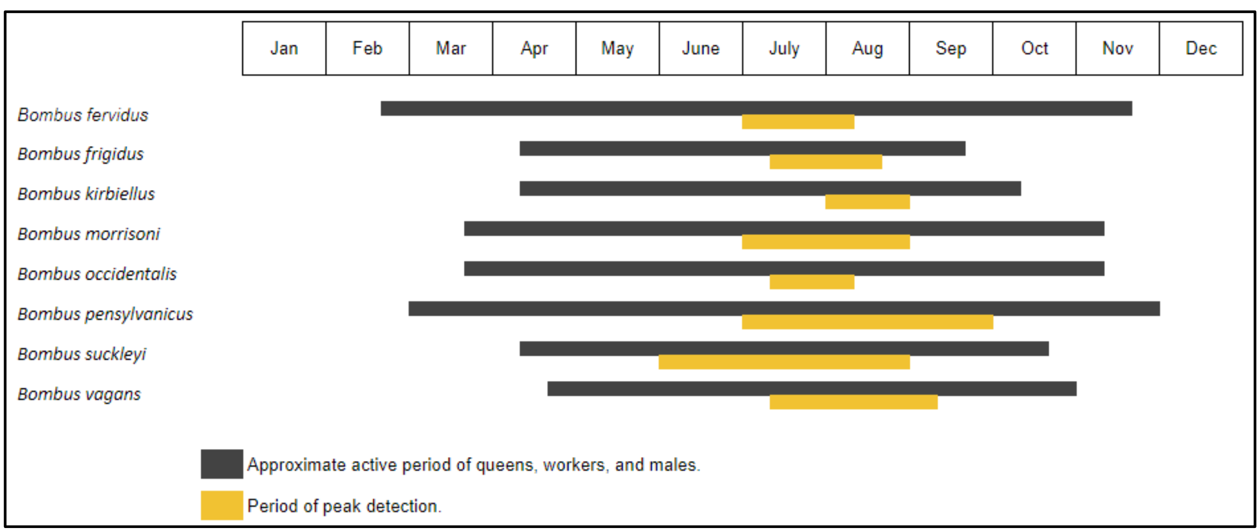


Figure 2. Approximate timing of species' active periods based on recorded observations throughout species' ranges in North America (Williams et al. 2014). Actual timing depends on a variety of factors including latitude, elevation, annual climate variability, and ecosystem characteristics.

Habitat

Bumble bees inhabit a wide variety of natural, agricultural, urban, and rural habitats, although species richness tends to peak in the flower-rich meadows of forests and subalpine zones (Goulson 2010). Records collected as part of the Pacific Northwest Bumble Bee Atlas (Xerces Society et al. 2022), 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 Oregon, Washington, and Idaho, suggest that the focal species of this publication are most often associated with grassland and meadows (39.25% of associations), followed by developed areas (32.32% of occurrences), riparian areas (10.48% of associations), woodland and forest (8.55% of associations), shrub and scrub (8.20% of associations), and agricultural lands (1.18% of associations) (Figure 3) (Hatfield et al. 2021b). These associations do not necessarily accurately represent habitat associations given sampling bias toward certain habitat types including developed areas near population centers. In order to complete their life cycle, bumble bees require suitable habitat for foraging, nesting, and overwintering. While these habitats are often overlapping or in close proximity to each other, each activity requires specific habitat elements.

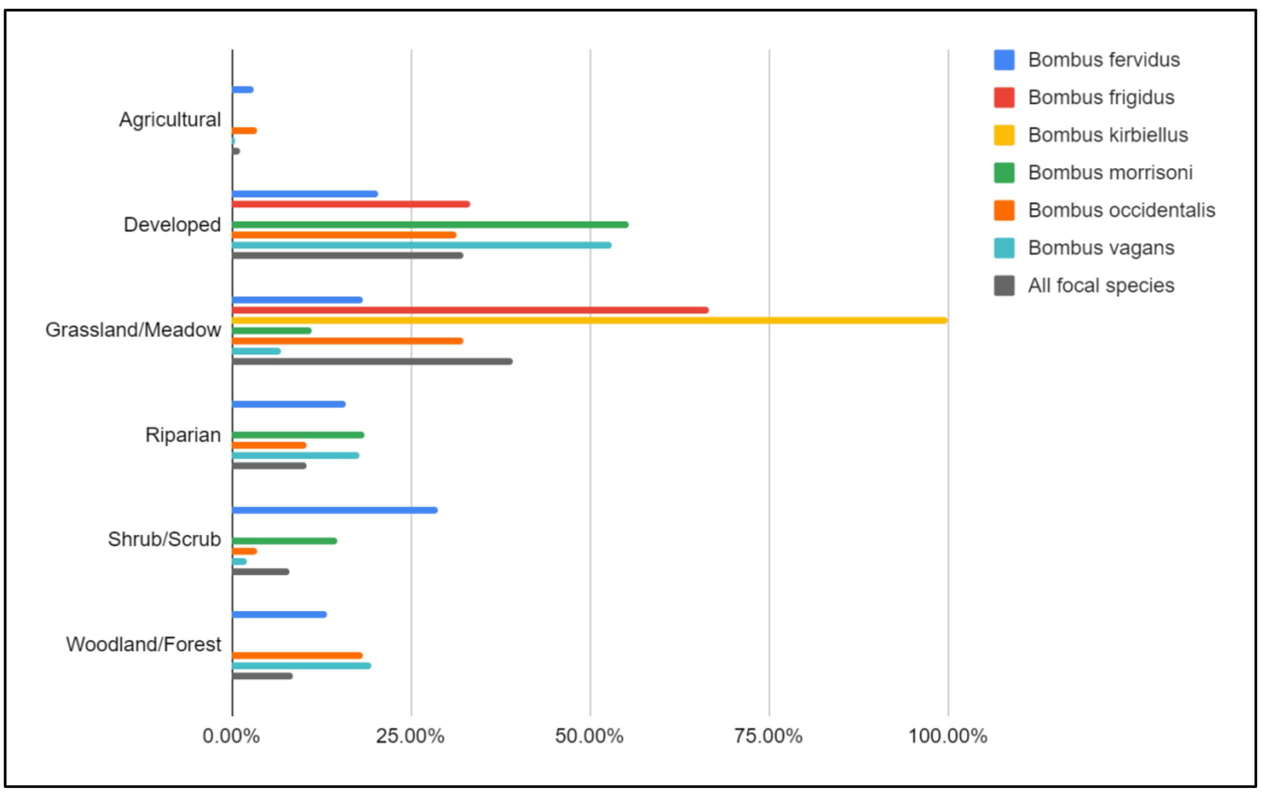
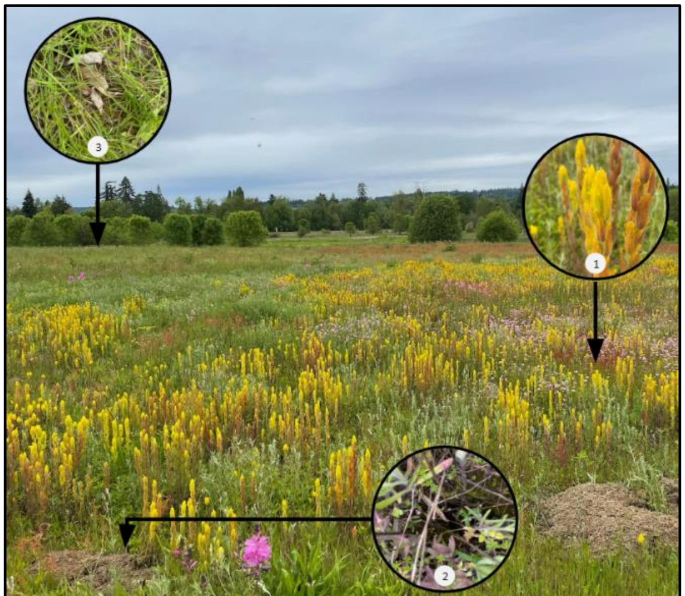


Figure 3. Habitat associations for focal bumble bee species. Data used to calculate the percentage of associations by habitat type was collected as part of the Pacific Northwest Bumble Bee Atlas and applies to Washington, Oregon, and Idaho (Xerces et al. 2022). Data is not available for *B. suckleyi* or *B. pensylvanicus*.

Foraging Habitat



High quality 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. Photos by the Xerces Society/Molly Martin.

Bumble bees require habitat with a diversity of plants flowering across the landscape throughout a species' active period (Figure 2), generally from early spring through fall, in order to support their colonies (Winfree et al. 2011, Cameron and Sadd 2020). The amount of pollen available to foragers affects the number of new queens that a bumble bee colony can produce, and since in eusocial species queens are the reproductive unit, pollen availability influences future bumble bee populations (Burns 2004). Active periods, during which the availability of floral resources is important for the initiation and maintenance of colonies, depends on a variety of factors including species, latitude, elevation, annual climate variability, and ecosystem characteristics. Records collected across species' ranges in North America suggest that the active periods for the eight focal species are within the range of late February through late November, though they will differ across elevations and habitat types (Figure 2) (Williams et al. 2014).

Bumble bees are primarily generalist foragers, visiting a wide range of plants to collect resources (nectar and pollen) (Hatfield et al. 2012). Multiple species of bumble bees may occupy the same habitat, with foraging niches partitioned to a certain extent by tongue length (Harder 1983, Miller-Struttmann et al. 2015). It is important to note that tongue length is related to body size, so there is substantial variation in tongue length, even within a species. Still, generally bumble bee species can be classified by their tongue length, and this dictates their foraging choices, to a certain extent. Long-tongued species are able to access nectar in tubular flowers with long corollas while short-tongued species primarily visit smaller, open-faced flowers. Some short-tongued species access nectar in plants with long corollas by biting holes at the base of the corolla, a behavior known as nectar robbing, which allows a bee to access nectar but does not facilitate pollination of the plant. Morrison bumble bee has a very short tongue, western bumble bee has a short tongue, Suckley cuckoo bumble bee has a short to medium tongue, frigid and half-black bumble bees have medium tongues, and yellow, golden-belted, and American bumble bees have long tongues (Williams et al. 2014). Morrison and western bumble bees have been observed engaging in nectar robbing behavior (Bently and Elias 1983, Williams et al. 2014).

Different species of bumble bees vary in their foraging distance, with estimates ranging from 275 m (900 ft) (Osborne et al. 1999) to 750 m (nearly ½ mi.) (Carvell et al. 2012). Maximum colony-specific foraging distances of over 11 km have been recorded when resources are not available near the nest (Rao and Strange 2012), however bumble bees generally forage closer to the nest in order to optimize the resources collected and minimize energy expended in flight (Heinrich 2004). Optimal foraging theory suggests that bumble bees preferentially forage close to their nests in order to reduce the energetic expenditure of longer flights (Heinrich 2004). Providing foraging habitat for bumble bees within around one km of suspected nesting habitat is recommended, regardless of the type of land cover between patches of floral resources (Mola et al. 2020).

The focal species of this conservation strategy are most often associated with grasslands and meadows as well as developed areas (Figure 3). Forests often provide important foraging habitat early in the season due to their high density of early-flowering plant species (Inari et al. 2012, Wray et al. 2014, Kämper et al. 2016, Mola et al. 2021), while other habitats including meadows and developed areas provide important mid- and late-season foraging habitat (Figure 3). Since early spring and late fall are often periods with fewer floral resources, the presence of flowering plants at these times is essential. Laboratory evidence suggests that a diet of more diverse pollen sources early in the season leads to more robust colonies later in the year (Watrous et al. 2019). Appendix C includes information on plants most often associated with specific species. Note that these floral associations do not necessarily represent a species' preference for these plants over other flowering plants, but rather may represent the abundance of these flowers in the landscape.

Nesting Habitat

Following overwintering, queen bumble bees become active in early spring and search for a suitable nest site. While relatively little is known about the habitats associated with bumble bee nests, bumble bees have been documented nesting in a variety of landscape types including agricultural, alpine, dune, forest, forest edge, grassland, tropical forest, and urban (Liczner and Colla 2019). A review of bumble bee nesting habitat identified grasslands, agriculture, and forests as the most common landscapes for bumble bee nests (Liczner and Colla 2019). Within these landscapes, nests are most commonly located underground, however they may also be found on or above the ground surface. Most species of bumble bees nest underground in abandoned rodent burrows or other preexisting cavities (e.g., grass tussocks, hollow logs, bird nests, rock piles) (Plath 1922, Hobbs 1968, Thorp et al. 1983, Macfarlane et al. 1994).

A western bumble bee nest excavated in central Oregon. The nest was located several feet underground. Photo by USFWS/Alan Yanahan.

Species that primarily nest belowground include the golden-belted, Morrison, western, and half-black bumble bees (Plath 1922, Hobbs 1968, Thorp et al. 1983, MacFarlane et al. 1994, Williams et al. 2014). Yellow and frigid bumble bees nest mostly above ground, often on the surface or in tall grass (Williams et al. 2014). Western bumble bee nests are primarily within underground cavities including old squirrel or other animal nests located in open slopes with a west-southwest facing slope, bordered by trees, although a few nests have been reported from above-ground locations including in logs among railroad ties (Plath 1922, Hobbs 1968, Thorp et al. 1983, Macfarlane et al. 1994). Availability of nest sites for the western bumble bee, as well as for other species that nest in abandoned rodent burrows, may depend on rodent abundance (Evans et al. 2008). Tunnels of western bumble bee nests have been reported to be up to 2.1 m long and the nests may be lined with grass or bird feathers (Macfarlane et al. 1994). Some species, including the western and yellow bumble bees, have been observed digging false entrances to their nests and camouflaging their nest entrances with moss or grass (Hobbs 1966a, 1968, Richards 1975, Lanterman et al. 2019). Since the Suckley cuckoo bumble bee is a parasitic species, its reproductive capacity relies on the availability of nests belonging to its primary host, the western bumble bee (Thorp et al. 1983).

Throughout the life cycle of a colony, queens and female workers collect nectar and pollen from flowering plants to feed the colony, and increasing floral resources in a landscape has been shown to increase bumble bee nest densities through increasing foraging efficiency (Osborne et al. 2008, Knight et al. 2009, Goulson 2010, Hatfield et al. 2021a). While nest sites may be located in habitat also suitable for foraging, nesting and foraging habitat may be separate (Lonsdorf et al. 2009). Nest sites act as a hub around which foraging habitat is distributed.

Overwintering Habitat

While habitat requirements for bumble bee overwintering and nesting are understudied, likely due to the challenges associated with locating these sites, studies suggest that the habitat in which queens overwinter is likely distinct from foraging and nesting habitat (Darvill et al. 2004, Waters et al. 2011, O'connor et al. 2017, Williams et al. 2019). A review of bumble bee overwintering and nesting habitat that included 10 overwintering habitat studies found queens generally overwinter underground, most often in shaded areas near trees as well as in banks without dense vegetation (Sladen 1912, Plath 1927, Bols 1937, Hobbs 1967, Alford 1969). Overwintering sites are generally located in areas without dense vegetation, in bare-earth, tree litter, moss, or in bare-patches within short grass (Sladen 1912, Plath 1927, Bols 1937, Hobbs 1965a, 1965b, 1967, Alford 1969). Overwintering queens are most often associated with north-facing slopes, likely to prevent early emergence on warm, sunny winter days, however may also be found in slopes with other aspects or flat ground (Sladen 1912, Plath 1927, Bols 1937, Hobbs 1967, Alford 1969). Overwintering sites are most often in areas with sandy, well-drained, or loose soil (Plath 1927, Bols 1937, Hobbs 1967, Alford 1969). Queens overwinter at varying depths within the soil in order to regulate their temperature and emerge at the optimal time (Hobbs 1966a, 1966b, 1967, Alford 1969, Szabo and Pengelly 1973). Overwintering depth for a variety of species has been found to be between two and 15 cm (Liczner and Colla 2019). While very little is known about hibernacula for specific species, Hobbs (1968) reported western bumble bee hibernacula that were two inches deep on the west slope of a steep mound of earth. The closely related buff-tailed bumble bee (*Bombus terrestris*) reportedly hibernates beneath trees (Sladen 1912).

METHODS

Overview

We completed a variety of analyses in order to translate available information about bumble bee species and geographic, environmental, and anthropogenic factors in the state of Washington into actionable conservation recommendations. To inform this process, we modeled species distribution (historic, recent, and trend) for all eight focal species. Once the species distribution models (SDMs) were complete, we used the mean of the eight species' probability of presence (based on the predicted potential geographic distribution) to rank level IV ecoregions by conservation priority, with high priority areas having the highest mean probability of species presence. Next, we developed a threat matrix and analyzed those threats spatially in order to understand potential threats and their impacts across regions identified as priorities for the conservation of the eight bumble bee species included in this conservation strategy.

In order to provide additional information to enable land owners and land managers to identify focal areas for conservation efforts, we analyzed the overlap of predicted potential geographic distribution, priority areas, and occurrence records with property ownership and management. Additionally, this information allows land owners and managers to consider the overlap between existing projects and priority areas for bumble bee conservation.

Finally, we looked at the primary land cover (or covers) within each priority ecoregion and developed management recommendations by land cover class. Land cover classes include forest, shrub/scrub, herbaceous, cultivated crops and hay/pasture, development, and woody wetland. We also provide best management practices for a variety of management activities.

The information presented in this conservation strategy enables the development of management plans and implementation of conservation actions that take into account the status of priority bumble bee species, potential threats and current land use, as well as major land cover types. We provide guidance for a range of practitioners, project scales, and objectives.

We developed an interactive online map that allows users to view information in unique combinations and at varying scales, customized to their needs. This map allows information to be displayed, including potential threats and land cover, at a finer scale than is included in the current strategy. This map can be accessed at: https://xerces.org/publications/strategy-bumble-bee-species-conservation-concern.

The following sections provide an overview of methods. See Appendix F for a more comprehensive methods section. Appendix B includes additional results not included in the body of this conservation strategy.

Data

We sourced occurrence records of the eight focal bumble bee species from a database of more than 700,000 records of 43 species of North American bumble bees first assembled 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 (Xerces Society et al. 2022). This project has substantially expanded the number and geographic distribution of bumble bee records in the Pacific Northwest, providing key information to inform conservation strategies such as this.

Assumptions

Selecting priority management areas based on known occurrences of a species presents challenges when addressing the conservation needs of bumble bees. Given that bumble bees are physically small and spend a significant portion of their life cycle (Figure 2) in nests and hibernacula, we can assume that many populations of bumble bees, and particularly rare bumble bees, have not been detected. While the Pacific Northwest Bumble Bee Atlas (Xerces Society et al. 2022) has increased the number of bumble bee records collected, only a small fraction of the state's suitable habitat has been surveyed. Additionally, bumble bee records tend to be clustered around human population centers as a result of high sampling effort. Despite the tendency towards clusters of occurrence records near population centers, we assume that bumble bee habitat is broadly distributed across the state. We therefore conclude that selecting priority management areas based on known occurrences alone would significantly limit conservation opportunities.

While a number of the species included in this conservation strategy only overlap with Washington state at the edge of their ranges (the frigid, golden-belted, and American bumble bee), these species have been included under the assumption that changes in environmental variables driven by climate change will likely continue to result in range shifts. Creating and maintaining habitat suitable for these species, even on the margins of their current ranges, will increase the likelihood of species persistence.

Selection Criteria for Priority Management Areas

We used level IV ecoregions as the unit for priority area selection and data analysis. Level IV ecoregions are ecologically relevant units at a scale that allows for feasible analysis while also providing the specificity required for developing effective management recommendations. Washington state is composed of 57 level IV ecoregions (Figure 4).

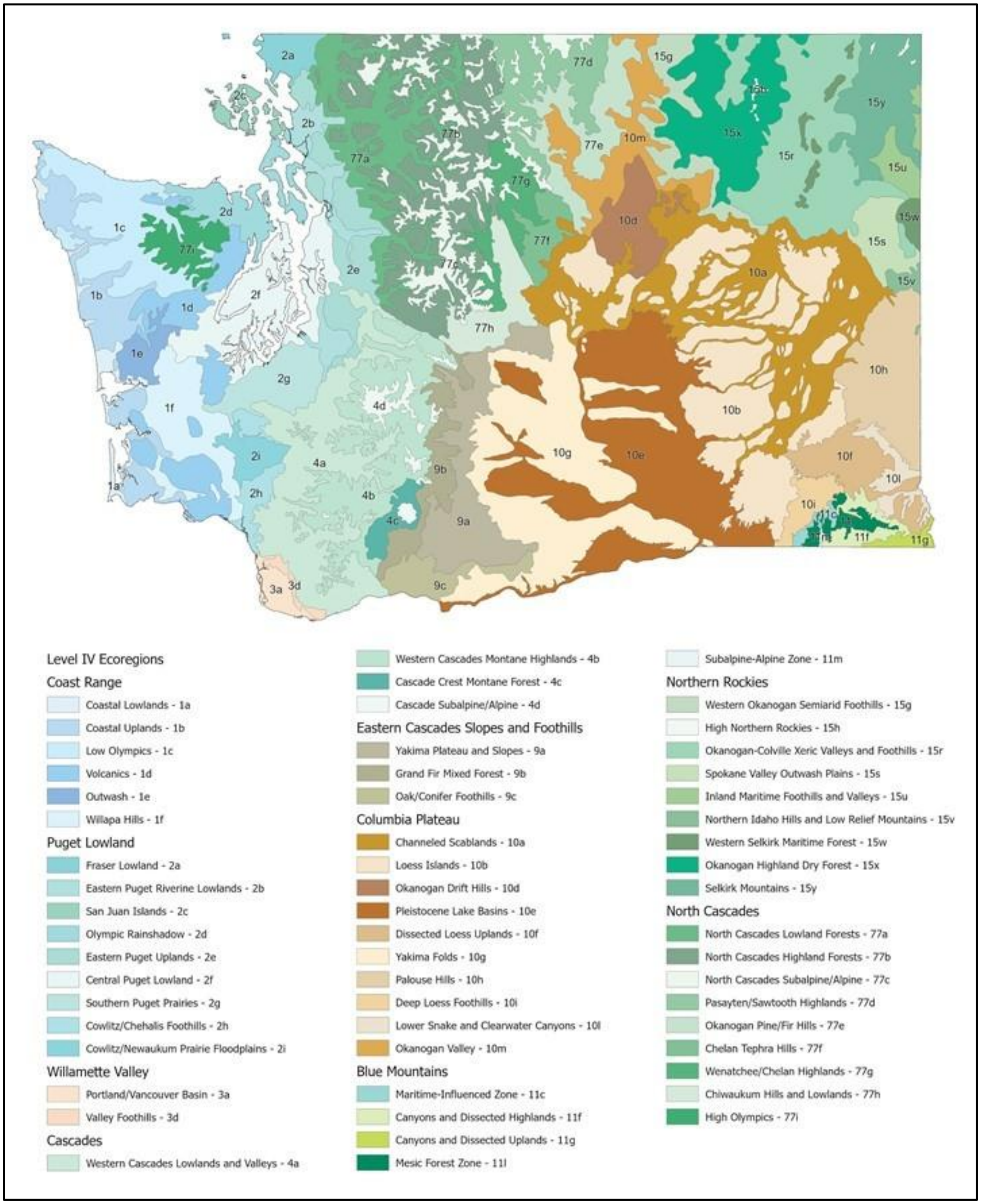


Figure 4. Level IV ecoregions of Washington (EOA 2022). In the legend, level IV ecoregions are grouped by level III ecoregion, with headings indicating level III ecoregions.

Due to the limitations of identifying priority areas based on recorded observations alone, we identified priority areas through modeling species distribution. 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) uses recent 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) to construct a model of predicted potential geographic distribution. Results of these SDMs should be interpreted with caution given that the models included presence only data (as opposed to presence and absence data), and the predictor variables used in the models do not represent all factors impacting bumble bee distribution. As such, these SDMs should be interpreted as predicted potential geographic distributions (where suitable habitat exists to support these species).

We modeled species distribution for all eight species of interest for both the recent (2011-2021) and historic (2010 and earlier) time periods. We determined the priority of level IV ecoregions by dividing the mean predicted probability of presence for all focal species into three categories, “low”, “medium”, and “high”. SDMs were also used to create maps of suitable habitat, and therefore predicted potential geographic distribution, for each species in North America and in Washington state.

While the average of SDMs for all focal species based on recent occurrence records provides a method for assessing the status of multiple species for a snapshot in time, considering the trend in average predicted potential geographic distribution can inform where limited conservation resources should be focused. We calculated the difference between historic (pre-2011) and recent (2011-2021) average probability of species occurrence for medium and high priority level IV ecoregions.

In order to include recent occurrence records that fall outside of ecoregions we identified as medium or high priority, and to ensure that areas around known recent occurrences of focal species were explicitly incorporated in conservation opportunities, we mapped 10 km buffers around known recent occurrences for all eight focal species. We used 10 km buffers since this is approximately the farthest distance that bumble bees have been recorded to travel from their nest (Goulson 2010), and has also been used by the FWS as the scale at which bumble bee populations exist (USFWS 2020).

In addition to analyzing the cumulative probability of any of the eight focal species being present in any given level IV ecoregion, we calculated the number of species potentially present in each medium and high priority level IV ecoregion for both the recent (2011-2021) and historic (pre-2011) time periods based on the results from SDMs. We considered a species to potentially be present in an ecoregion if any portion of its modeled distribution, above the threshold determined during the SDM process, overlapped that ecoregion.

Appendix F includes a complete description of methods used to model species distribution and select high priority areas.

Land Cover

We grouped level IV ecoregions identified as medium and high priority for the conservation of the eight focal species included in this conservation strategy by land cover. A given ecoregion is included in a land cover grouping if more than ten percent of that ecoregion is composed of that land cover class. We included level IV ecoregions in multiple land cover categories if more than one land cover class covers 10 percent or more of the ecoregion. Land cover classes include forest, shrub/scrub, herbaceous, cultivated crops and hay/pasture, development, and woody wetland. Categorizing priority areas by land cover, and therefore likely land use, allows for the planning and implementation of more specific management actions.

Ownership and Management

Understanding the status of ownership and management of property in priority ecoregions allows for targeted management by federal and state agencies as well as potential outreach to other owners of land in priority areas, including private landowners and Tribal Nations. We calculated the percent of each priority ecoregion, number of occurrence records for all species of interest, and the predicted potential geographic distribution overlap of each focal species by land owner and manager. For the predicted potential geographic distribution overlap analysis we calculated the overlap of predicted potential geographic distributions with each level IV ecoregion.

Analysis of Potential Threats and Forces Shaping Ecosystems

In order to characterize potential threats and their impacts across regions identified as priorities for the conservation of the eight bumble bee species included in this conservation strategy, we developed a threat matrix and analyzed those threats spatially. For potential threats with adequate available data, we quantified mean value of each individual threat by level IV ecoregion. We set all mean threat values for each individual potential threat on a scale of zero to one. We then calculated the mean of all potential threats with adequate data by level IV ecoregion.

Based on limitations to data quality and variations in threat scale and scope, we included the following potential threats in our spatial analysis: agriculture and development, grazing, fire, pesticides, and climate change. Additional potential threats that are important to understanding the distribution and conservation of these species are included in the ‘Analysis of Potential Threats and Forces Shaping Ecosystems’ section below.

Agriculture and Development

We estimated the potential threat posed by agriculture and development across the state using the land cover vulnerability to change model (Clark University 2021), which predicts human-based land cover changes and projects the extent of these changes to the year 2050.

Grazing

We assessed the effects of grazing on public lands using data on current and past grazing allotments on lands managed by the USFS (USDA Forest Service 2022) and BLM (Bureau of Land Management 2022). We included active and historic grazing allotments to estimate the spatial distribution of grazing threats in the past, present, and future. Our analysis of grazing only includes public lands grazing on USFS and BLM land and does not consider grazing on private land or Tribal Nations. While grazing does occur on WDFW land, this was not included in the analysis given the allotments cover a relatively small area.

Wildfire

We analyzed the probability of future wildfire using data from the Wildfire Hazard Potential dataset (Dillon et al. 2015). This analysis does not include prescribed burns.

Pesticides

We mapped pesticide use with the most recent data compiled by the U.S. Geological Survey estimating annual agricultural use of pesticides in counties of the conterminous United States in 2019 (Wieben 2021). From all pesticides, we created a subset for these analyses including insecticides and fungicides moderately and highly toxic to bees that were found to exceed regulatory limits in surface water in Washington state (Noland et al. 2021). This included the following active ingredients: Boscalid, Carbaryl, Chlorpyrifos, Clothianidin, Dimethoate, Fipronil, Imidacloprid, Malathion, Mycobutanil, Propiconazole, and Thiamethoxam. We estimated overall pesticide impact by calculating the average of summed pesticide application within each level IV ecoregion. This evaluation of potential risk to bumble bees is limited in inference scope, as it only includes estimates from agricultural pesticide applications and not other varied uses, such as residential applications, vector control (mosquito management) applications, or applications to rangelands or forested areas. Non-agricultural applications make up a substantial proportion of pesticide use across the state, but there is limited information available on amounts or locations to which they are applied. Applications of agricultural insecticides in the form of seed coatings are also excluded from this analysis, as they are not currently regulated as pesticides by the US EPA, despite widespread use in corn, soybeans, and other row crops.

Climate Change

We assessed the potential impact of climate change by analyzing the net change between historical and modeled future minimum temperature, maximum temperature, and precipitation. We used these factors as all three are significant measurements of climate and emerged as important factors in the SDMs that we built for the eight focal species. We sourced the data from the WorldClim database, a high spatial resolution global weather and climate dataset (WorldClim 2022). This database was also the source of climate and weather data used as inputs to the SDMs. We compared the average current minimum temperature, maximum temperature, and precipitation by level IV ecoregion from the historical time period (1970-2020) to projected future (2021-2040) values. We then calculated potential climate departure, a measure of the threat posed by climate change, as the difference between historic and projected future climate conditions for those three variables.

PRIORITY MANAGEMENT AREAS

High Priority Areas

Prioritization of level IV ecoregions reflect the mean predicted probability of presence of the eight focal species. Of Washington's 57 level IV ecoregions (Figure 4), 19 ecoregions qualify as each priority level; high, medium (Table 2), and low (Table B 10, Figure 1). The high priority ecoregions are generally distributed in a horseshoe shape around the Columbia Plateau, from the Yakima Plateau and Slopes in the southwest, north along the eastern foothills of the North Cascades to the Okanogan Pine/Fir Hills, Okanogan Valley, and Western Okanogan Semiarid Foothills, east to the Selkirk Mountains, and south through the Palouse Hills. Medium priority ecoregions generally surround the high priority ecoregions with the exception of a band of medium priority ecoregions through the Puget Lowlands to the Fraser Lowlands. While this document focuses on management to improve habitat within high and medium priority ecoregions, equal effort needs to be focused on maintaining high quality habitat where it already exists (e.g., higher elevations of the Cascades), regardless of ecoregion priority.

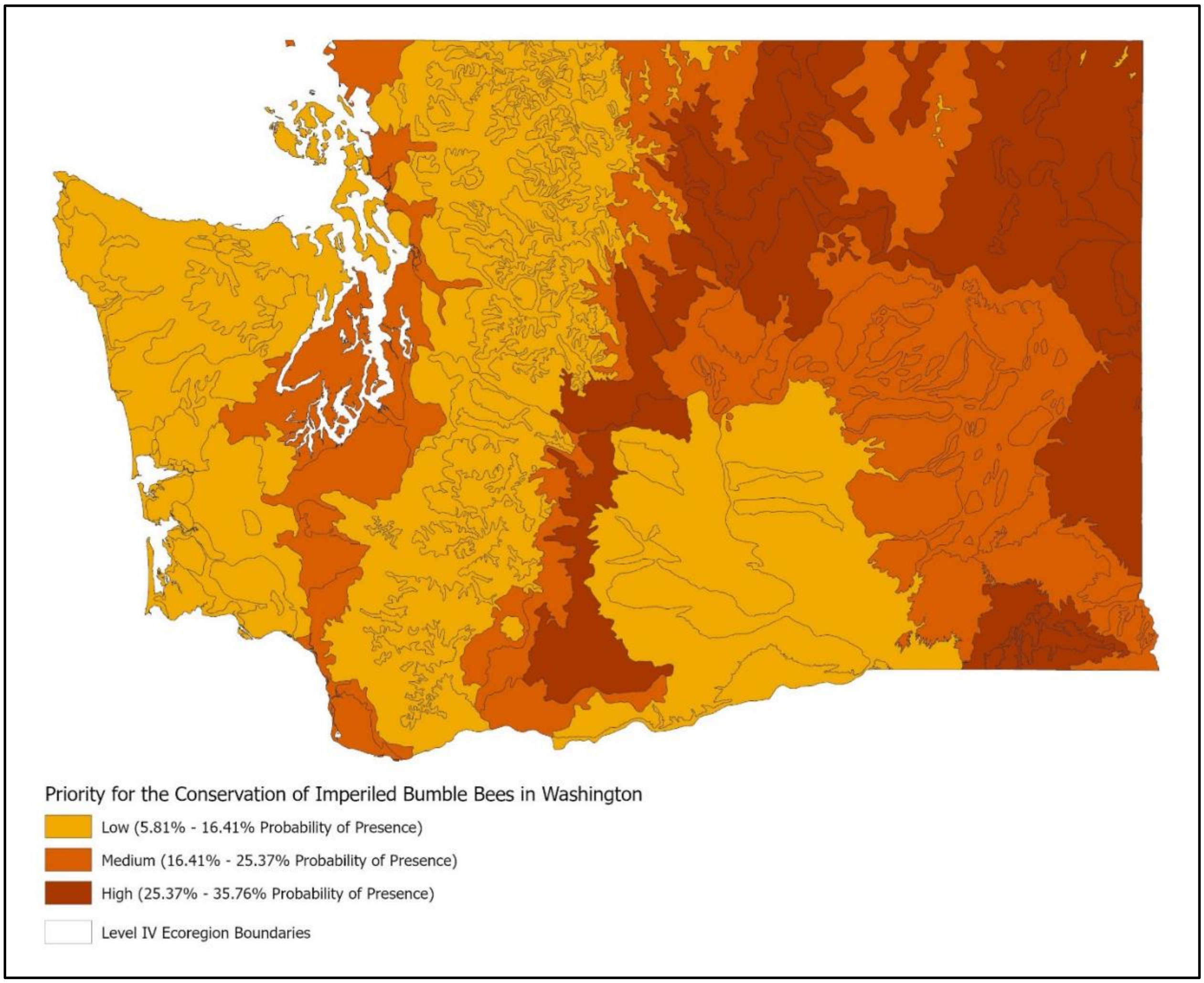


Figure 1. Mean probability of presence for all focal species based on modeled species distribution during the recent (2011 - 2021) time period. Ecoregions in red indicate the highest priority for conserving imperiled bumble bees, ecoregions in orange indicate medium priority, and ecoregions in yellow indicate low priority.

Table 2. High and medium priority level IV ecoregion based on mean recent predicted probability of presence. Mean predicted probability of presence for the recent (2011-2021) and historic (pre-2011) time periods is an average of the estimated probability that any of the focal species will be present in the ecoregion based on SDMs. Red highlighting indicates high priority ecoregion and orange highlighting indicates medium priority ecoregions. The table is organized by mean recent predicted probability of presence from high to low.

Ecoregion	Priority	Mean Recent Predicted Probability of Presence (2011-2021)	Mean Historic Predicted Probability of Presence (pre-2011)	Change in Mean Predicted Probability of Presence
Spokane Valley Outwash Plains	High	35.76%	32.95%	2.81%
Inland Maritime Foothills and Valleys	High	33.20%	28.60%	4.60%
Maritime-Influenced Zone	High	32.84%	27.31%	5.54%
Northern Idaho Hills and Low Relief Mountains	High	31.97%	29.22%	2.75%
Palouse Hills	High	31.32%	28.16%	3.16%
Canyons and Dissected Highlands	High	31.06%	27.32%	3.74%
Mesic Forest Zone	High	31.00%	25.52%	5.48%
Okanogan Drift Hills	High	30.91%	28.82%	2.09%
Subalpine-Alpine Zone	High	30.14%	26.20%	3.94%
Western Selkirk Maritime Forest	High	29.25%	28.49%	0.76%
Okanogan Valley	High	28.87%	25.00%	3.86%
Okanogan Pine/Fir Hills	High	28.87%	27.16%	1.71%
Chiwaukum Hills and Lowlands	High	28.58%	21.32%	7.26%
Okanogan-Colville Xeric Valleys and Foothills	High	28.44%	22.33%	6.11%
Chelan Tephra Hills	High	28.17%	22.04%	6.13%
Western Okanogan Semiarid Foothills	High	28.13%	26.32%	1.81%
Deep Loess Foothills	High	27.30%	26.99%	0.31%
Selkirk Mountains	High	27.18%	28.35%	-1.18%
Yakima Plateau and Slopes	High	26.96%	19.34%	7.62%
Canyons and Dissected Uplands	Medium	25.37%	25.75%	-0.38%
Dissected Loess Uplands	Medium	24.55%	24.39%	0.15%

Ecoregion	Priority	Mean Recent Predicted Probability of Presence (2011-2021)	Mean Historic Predicted Probability of Presence (pre-2011)	Change in Mean Predicted Probability of Presence
Oak/Conifer Foothills	Medium	24.44%	20.25%	4.19%
Wenatchee/Chelan Highlands	Medium	22.78%	25.17%	-2.39%
Channeled Scablands	Medium	22.59%	15.95%	6.64%
Pasayten/Sawtooth Highlands	Medium	22.41%	27.69%	-5.28%
Grand Fir Mixed Forest	Medium	22.35%	24.85%	-2.49%
Okanogan Highland Dry Forest	Medium	22.22%	12.47%	9.75%
Loess Islands	Medium	22.07%	15.92%	6.15%
Portland/Vancouver Basin	Medium	21.83%	33.12%	-11.29%
Central Puget Lowland	Medium	21.64%	32.65%	-11.01%
Lower Snake and Clearwater Canyons	Medium	21.49%	24.22%	-2.73%
Southern Puget Prairies	Medium	21.43%	29.29%	-7.86%
Cowlitz/Newaukum Prairie Floodplains	Medium	19.95%	27.54%	-7.59%
Eastern Puget Riverine Lowlands	Medium	19.72%	36.05%	-16.33%
Cowlitz/Chehalis Foothills	Medium	19.56%	27.16%	-7.60%
Fraser Lowland	Medium	19.33%	39.40%	-20.06%
Valley Foothills	Medium	17.88%	25.17%	-7.30%
Cascade Crest Montane Forest	Medium	17.70%	27.50%	-9.79%

For the eight focal species, high priority areas based on the mean predicted potential geographic distribution represent recent occurrence records fairly well (Figure 5). The majority of occurrence records fall within the horseshoe of medium and high priority ecoregions around the Columbia Plateau and in the Puget Lowlands area. However, some clusters of recent occurrence records fall outside of ecoregions identified as medium or high priority in our analysis. For example, a cluster of occurrence records fall within the Western Cascades Montane Highlands, Cascade Subalpine/Alpine, and Cascade Crest Montane Forest ecoregions. Similarly, a cluster of occurrence records fall within ecoregions on the northeast region of the Olympic Peninsula. As these observations are significant, and to ensure that areas around known recent occurrences of focal species are explicitly incorporated in conservation opportunities, we mapped 10 km buffers around known recent occurrences for all eight focal species (Figure 5). These ecoregions are generally occupied by only a few species rather than a higher number of species, as is often the case for the medium and high priority ecoregions (Figure A 1). We address ecoregions with a high number of occurrence records, but low priority ranking based on SDMs (Table 3) for all species separately in the 'Applying Best Management Practices Across a Landscape: Management Recommendations by Land Cover' section below (Table B 17, Table B 19, Table B 21, Table B 23, Table B 25).

When interpreting the distribution of occurrence records it is important to note that while bumble bees likely inhabit areas with high quality habitat and few threats, occurrence records are also impacted by the locations where observers are most likely to look for these species. These locations are often skewed toward regions where species are expected to occur (likely in high quality habitat with few threats) as well as areas in close proximity to population centers. Recent efforts, specifically the Pacific Northwest Bumble Bee Atlas, have worked to decrease the impact of sampling bias on the geographic distribution of recorded bumble bee occurrences (Xerces et al. 2022).

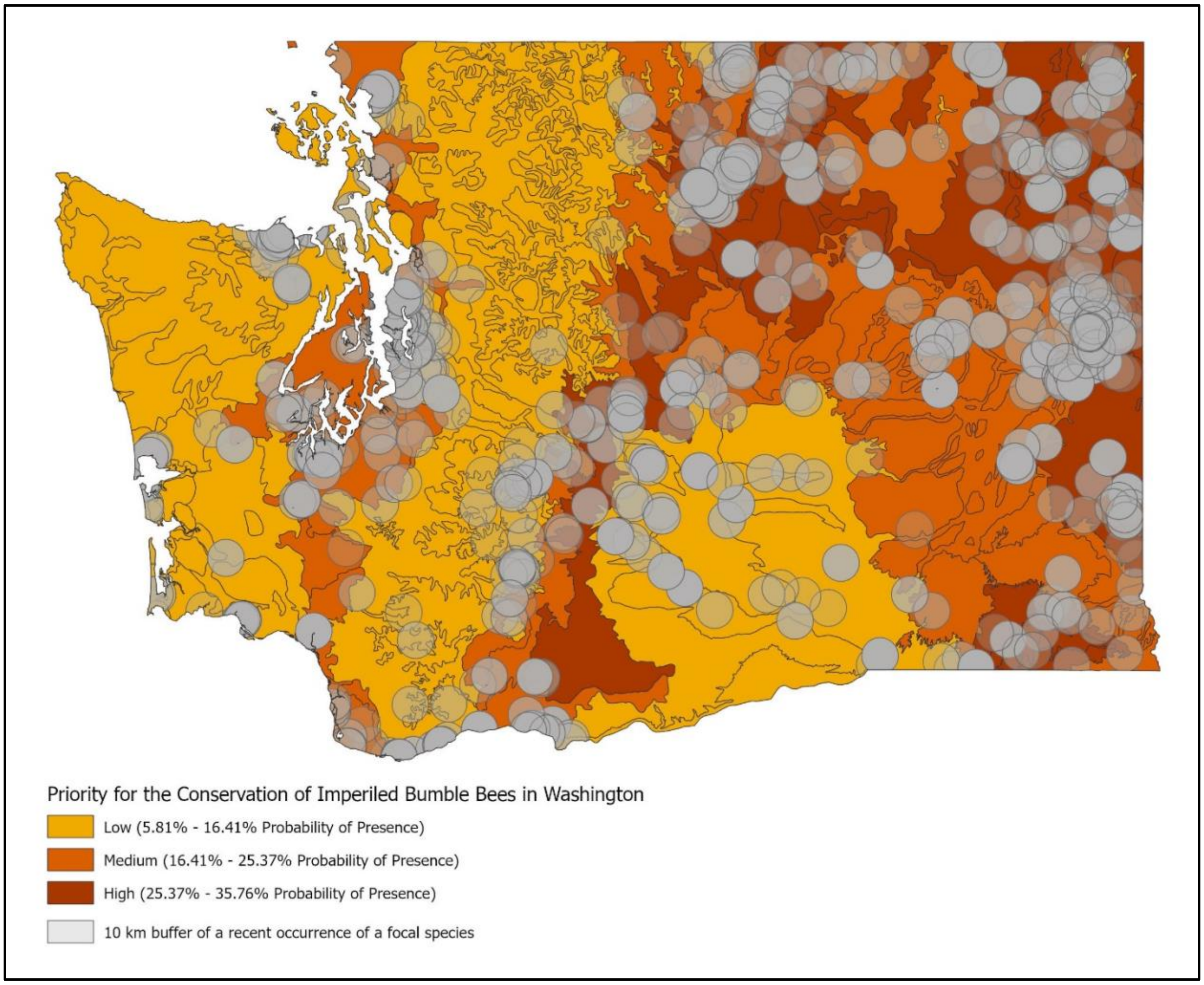


Figure 5. Mean predicted probability of presence for all focal species based on SDMs overlaid with areas within 10 km of a recent (2011-2021) occurrence record of a focal species. See Figure A 1 for the distribution of occurrence records by species.

Table 3. Low priority level IV ecoregions important for the conservation of specific focal species based on recent (2011-2021) occurrence records.

Ecoregion	**Total Occurrence Records of Focal Species**	**Number of Pacific Northwest Bumble Bee Atlas Surveys**	**Recent *B. fervidus* Occurrence Records (2011-2021)**	**Recent *B. frigidus* Occurrence Records (2011-2021)**	**Recent *B. kirbiellus* Occurrence Records (2011-2021)**	**Recent *B. morrisoni* Occurrence Records (2011-2021)**	**Recent *B. occidentalis* Occurrence Records (2011-2021)**	**Recent *B. suckleyi* Occurrence Records (2011-2021)**	**Recent *B. vagans* Occurrence Records (2011-2021)**	**Recent *B. pensylvanicus* Occurrence Records (2011-2021)**
Olympic Rainshadow	30	36	3	0	0	0	27	0	0	0
Yakima Folds	18	39	18	0	0	0	0	0	0	0
Eastern Puget Uplands	16	13	13	0	0	0	3	0	0	0
Cascade Subalpine/ Alpine	13	7	0	0	0	0	13	0	0	0
Western Cascades Lowlands and Valleys	11	21	9	0	0	0	2	0	0	0
North Cascades Subalpine/ Alpine	6	11	0	1	3	0	1	1	0	0
Western Cascades Montane Highlands	11	22	1	0	0	0	10	0	0	0

Ecoregion	Total Occurrence Records of Focal Species	Number of Pacific Northwest Bumble Bee Atlas Surveys	Recent *B. fervidus* Occurrence Records (2011-2021)	Recent *B. frigidus* Occurrence Records (2011-2021)	Recent *B. kirbiellus* Occurrence Records (2011-2021)	Recent *B. morrisoni* Occurrence Records (2011-2021)	Recent *B. occidentalis* Occurrence Records (2011-2021)	Recent *B. suckleyi* Occurrence Records (2011-2021)	Recent *B. vagans* Occurrence Records (2011-2021)	Recent *B. pensylvanicus* Occurrence Records (2011-2021)
High Olympics	4	2	0	0	0	0	4	0	0	0

Additional Conservation Opportunity Areas Based on Trends in Predicted Potential Species Distribution Over Time

While the average predicted potential geographic distribution for all focal species based on recent occurrence records provides a method for assessing the status of multiple species for a snapshot in time, considering the trend between historic (pre-2011) and recent (2011-2021) average predicted potential geographic distribution can inform where limited conservation resources should be focused. The change in mean predicted probability of species presence ranges from a decline of 21.52% to an increase of 9.75% (Figure 6). Ecoregions where predicted probability of presence has increased are generally located in a horseshoe around the Columbia Plateau. Areas where predicted probability of presence have decreased include those in mountainous areas including along the Cascade Range, in the Selkirk Mountains, and in the Blue Mountains as well as throughout the Puget Lowlands.

Interestingly, the majority of high priority ecoregions have an upward trend in mean predicted probability of presence while many medium priority ecoregions have a downward trend. This may indicate that maintaining habitat should be prioritized in high priority areas while restoring habitat is more important in medium priority areas. Regardless of the trend in mean predicted probability of presence, maintaining and improving habitat for bumble bees will positively impact these imperiled species. Additionally, it is important to note that the magnitude of declines far exceed the magnitude of increases. Additionally, these trends reflect mean predicted probability of presence, meaning that the trend in a single species' predicted probability of presence may be driving the overall trend. Looking more closely at the status and trend of each species individually will inform a more detailed understanding of each species' relative contribution to these aggregate trends (Figure A 3, Figure A 5, Figure A 7, Figure A 9, Figure A 11, Figure A 13, Figure A 15, Figure A 17, Table B 2, Table B 3, Table B 4, Table B 5, Table B 6, Table B 7, Table B 8, Table B 9).

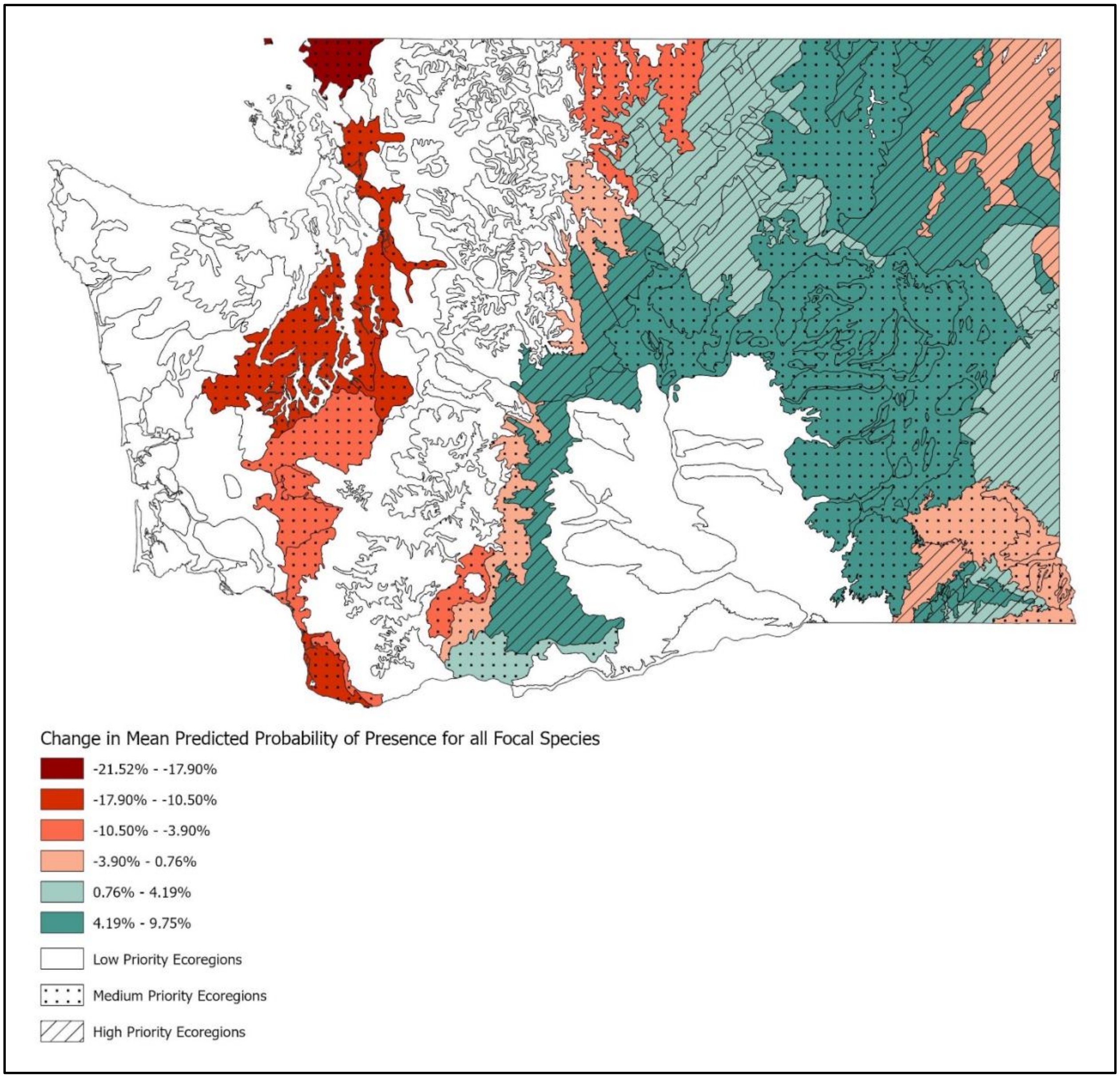


Figure 6. Change in the mean predicted probability of presence for all focal species within each level IV ecoregion designated as medium or high priority for conservation. Change in expected number of species is based on the difference between SDMs for the historic (pre-2011) and recent (2011-2021) time periods.

Species Overlap by Ecoregion

The number of species expected in a priority ecoregion (Figure 7, Table B 12) as well as the trend in the number of expected species (Figure 8, Table B 12) when comparing historic (pre-2011) numbers to recent (2011-2021) time periods informs the type of management that we recommend. Based on the results of the SDMs, medium and high priority level IV ecoregions may be occupied by between three and eight species (Table B 12). All eight species may be present in two priority ecoregions, both located on the east slope of the North Cascades and the north end of the Columbia Plateau: Chelan Tephra Hills and Okanogan Drift Hills. Seven species are expected in the Spokane Valley Outwash Plains, Palouse Hills, Northern Idaho Hills and Low Relief Mountains, Canyons and Dissected Highlands, Mesic Forest Zone, Okanogan Valley, Okanogan Pine/Fir Hills, Western Okanogan Semiarid Foothills, Inland Maritime Foothills and Valleys, Western Selkirk Maritime Forest, Okanogan-Colville Xeric Valleys and Foothills, Selkirk Mountains, Lower Snake and Clearwater Canyons, Wenatchee/Chelan Highlands, and Pasayten/Sawtooth Highlands ecoregions. Six species are expected in the Yakima Plateau and Slopes, Maritime-Influenced Zone, Deep Loess Foothills, Subalpine-Alpine Zone, Dissected Loess Uplands, Oak/Conifer Foothills, Channeled Scablands, Loess Islands, Portland/Vancouver Basin, Central Puget Lowlands, Eastern Puget Riverine Lowlands, Southern Puget Prairies, Cowlitz/Chehalis Foothills, Fraser Lowland, Canyons and Dissected Uplands, and Cowlitz/Newaukum Prairie Floodplains ecoregions. Five species are expected in the Chiwaukum Hills and Lowlands, Grand Fir Mixed Forest, and Okanogan Highland Dry Forest ecoregions, and four species are expected in the Cascade Crest Montane Forest ecoregion. Only three species are expected to be present in the Valley Foothills ecoregion in the southwestern portion of the state.

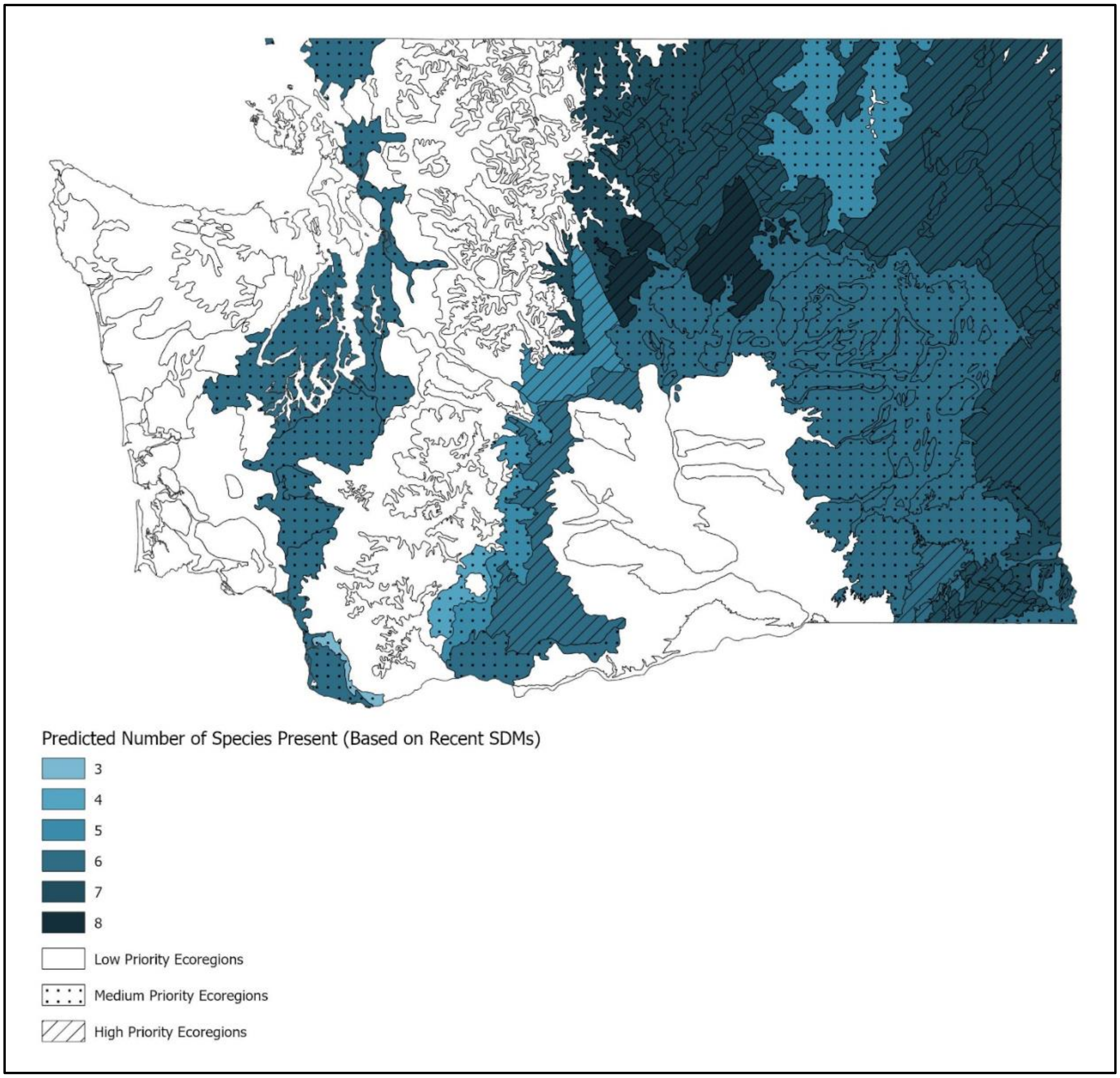


Figure 7. Combined number of focal species within each level IV ecoregion designated as medium or high priority for conservation. Expected number of species is based on SDMs for the recent time period (2011-2021).

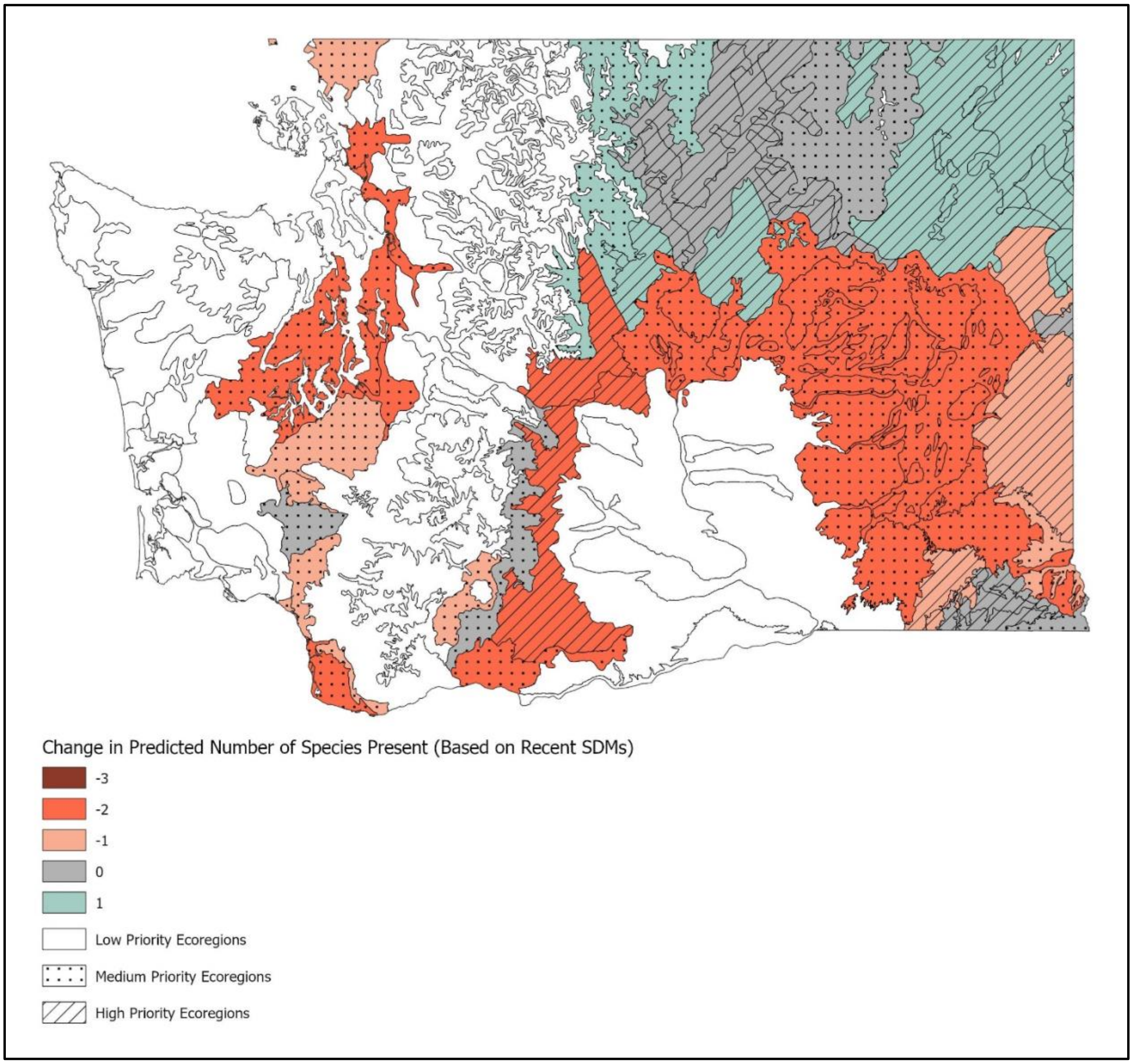


Figure 8. Change in combined number of focal species within each level IV ecoregion designated as medium or high priority for conservation. Change in expected number of species is based on the difference between SDMs for the historic (pre-2011) and recent (2011-2021) time periods. Note that a single low priority ecoregion, not displayed on this map, has experienced a decline of three species.

Ownership and Management

Understanding the status of ownership and management of property in priority ecoregions allows for targeted management by federal and state agencies as well as potential outreach to other owners of land in priority areas including private owners and Tribal Nations. The “other” category included in this section primarily refers to privately owned land and also includes land owned by Tribal Nations. We calculated the percent of each priority ecoregion (Table B 13), number of occurrence records for all species of interest (Figure 10, Figure 11, Table A 1, Table A 2, Table A 3, Table A 4, Table A 5, Table A 6,

Table A 7, Table A 8), and the predicted potential geographic distribution overlap of each focal species (Table A 1, Table A 2, Table A 3, Table A 4, Table A 5, Table A 6, Table A 7, Table A 8) by land owner and manager. For the predicted potential geographic distribution overlap analysis we calculated the overlap of species predicted potential geographic distribution above the threshold identified in the species distribution modeling process with each level IV ecoregion.

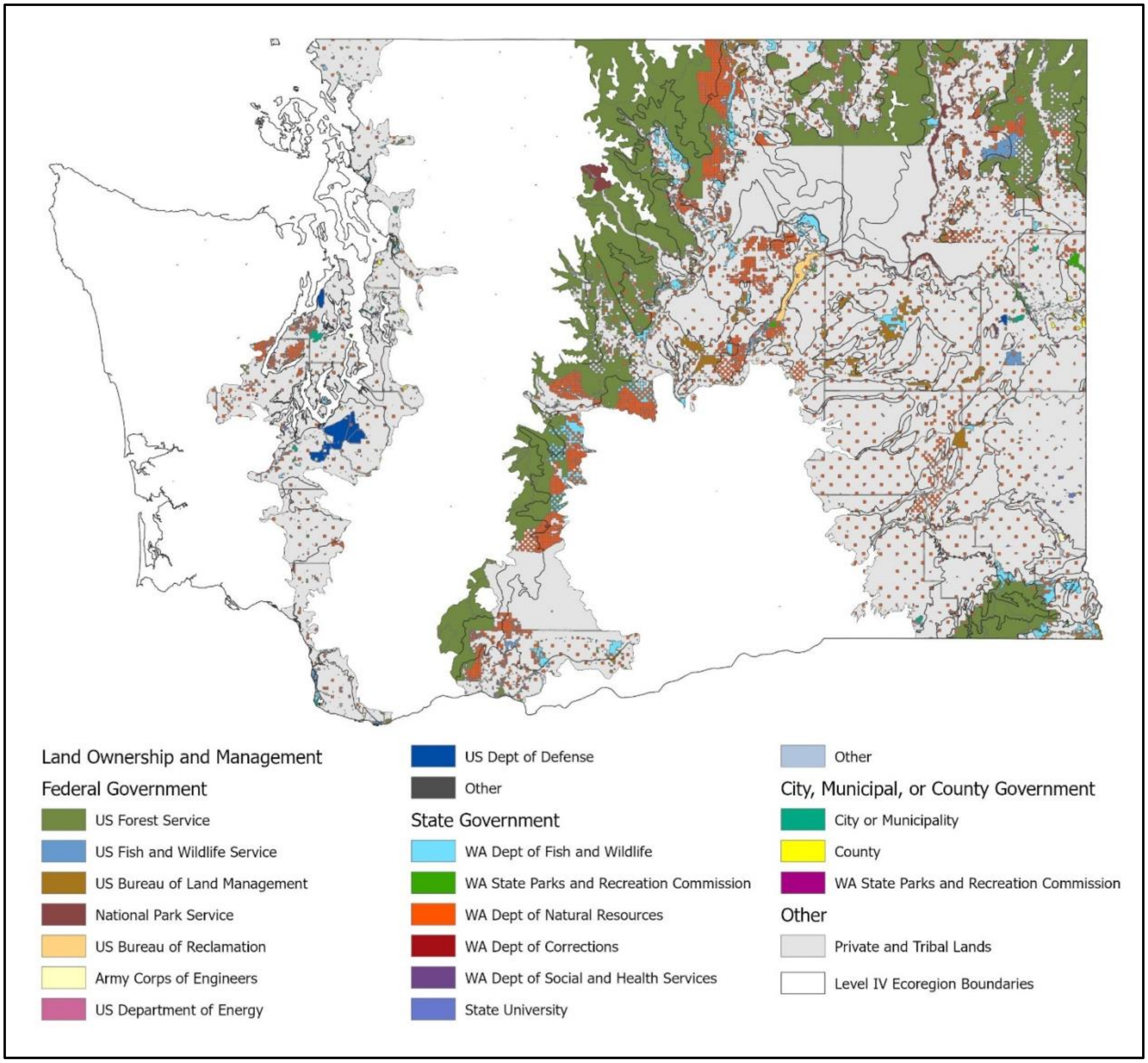


Figure 9. Land ownership and management within level IV ecoregions designated as medium or high priority for conservation. The small orange squares interspersed throughout the light gray private and Tribal lands are owned by the Washington Department of Natural Resources.

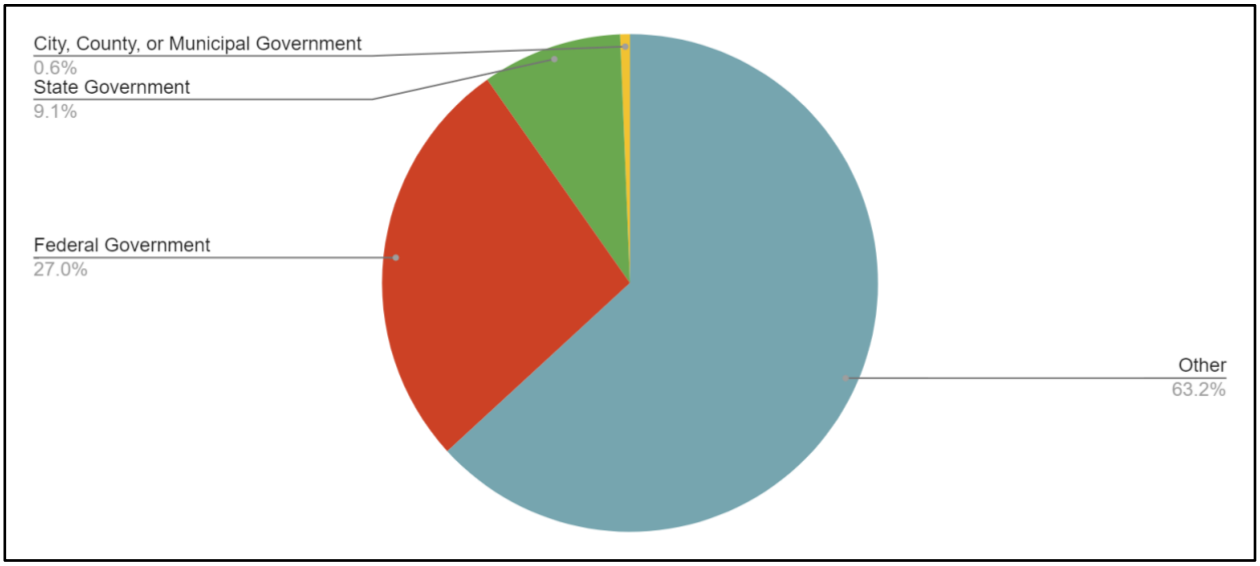


Figure 10. Percent ownership within level IV ecoregions designated as medium or high priority for conservation, showing higher level ownership categories.

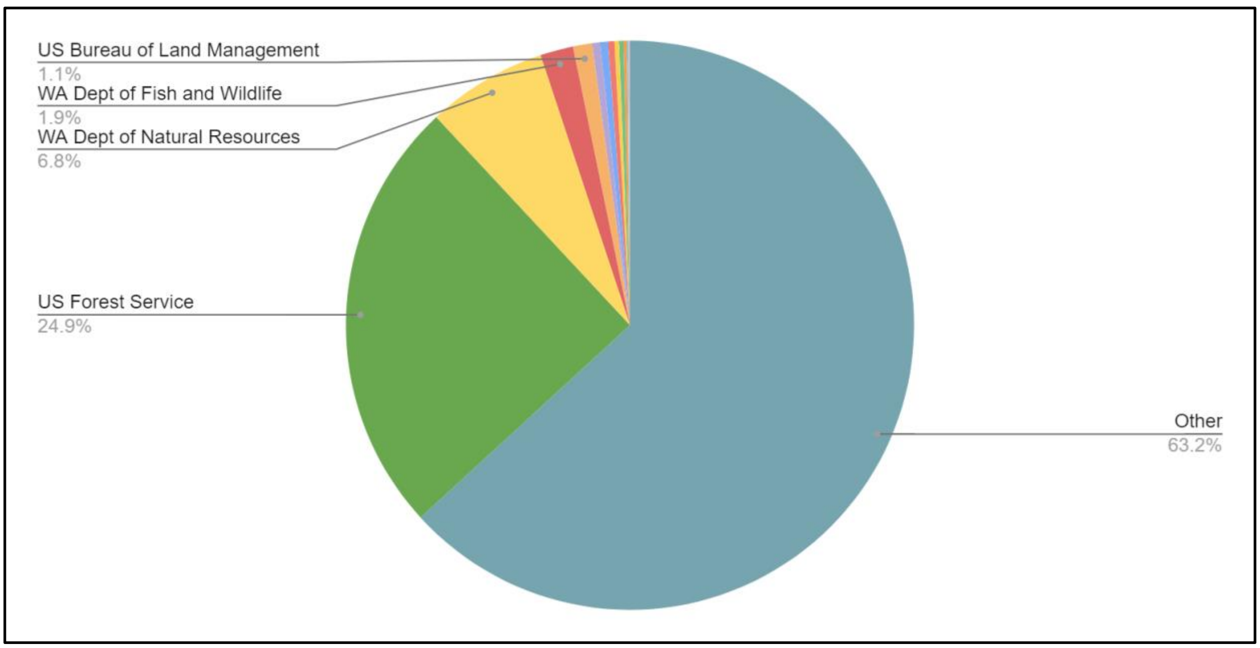


Figure 11. Percent land area by manager within level IV ecoregions designated as medium or high priority for conservation.

MANAGEMENT RECOMMENDATIONS

This conservation strategy includes information and resources for land managers to implement effective actions to conserve eight focal bumble bee species. Implementing these guidelines and best management practices will also benefit other pollinators as well as wildlife more generally. This section of the strategy provides general management recommendations, best management practices to mitigate potential threats (i.e., pathogens and competition from managed bees, agriculture and development, grazing, forest management, fire, pesticides, and climate change), and management recommendations by land cover type (i.e., forest, shrubland, herbaceous, planted/cultivated, development, and woody wetland), aimed at applying best management practices across a landscape. Finally, we present a framework for conservation planning.

General Management Recommendations

The most effective way to support bumble bees is by providing the habitat they rely on for foraging, nesting, and overwintering, and protecting that habitat from pesticides, pathogens, and other potential threats. The following guidance for maintaining high quality pollinator habitat should be considered in conjunction with best management practices and management recommendations by land cover.

In the following sections, recommendations that we suggest prioritizing are italicized.

Foraging Habitat

- *Maintain a diversity of native flowering plants through the active season for bumble bees (Figure 2) by protecting existing plant communities and supplementing native plant communities through restoration and adaptive management. A diverse plant community includes a variety of flower colors, shapes, sizes, plant structures, and bloom periods.*
- Prioritize protecting and planting plant species associated with the focal bumble bee species of this conservation strategy (Table 4, Appendix C).
- Choose native plants appropriate for your region, and not horticultural varieties that may not produce as plentiful or high quality nectar and pollen.
- Plant native flowering trees that provide an important food source, particularly during the spring and late summer.
- When creating bumble bee foraging habitat in arid landscapes, consider the extremes of current and future climate scenarios, and when possible seek plants that can withstand those conditions.
- Source seeds and seedlings that have not been treated with pesticides; avoid highly toxic systemic insecticides in particular.
- Once planted, avoid applying pesticides – including insecticides, fungicides, and herbicides – to bumble bee habitat and minimize potential contamination from drift, runoff, and leaching from

any applications close to foraging and nesting areas. Consider potential pesticide inputs in adjacent land uses and implement spatial or vegetative buffers as needed to help protect habitat from pesticide contamination.

- Follow best management practices to reduce negative impacts and promote positive impacts of management activities (e.g., grazing, logging, invasive species management, prescribed fire) on native flowering vegetation.
- *Focus particular attention on maintaining ample resources during the shoulder seasons - early spring for colony initiation and late summer when landscapes tend to dry out and resources are more limited. Examples of early nectar and pollen sources for emerging queen bumble bees in western Washington include Mahonia aquifolium, M. nervosa, Ribes sanguineum, and Arctostaphylos uva-ursi. In eastern Washington examples include Mahonia repens, Ribes viscosissimum, R. oxyacanthoides, R. aureum, and Arctostaphylos uva-ursi. Native species of willows (Salix spp.) also provide early nectar and pollen throughout Washington. See Table 4 and Appendix C for more information on selecting plant species.*

Table 4. Plant genera associated with bumble bee species of conservation concern along with approximate bloom times. Based on Hatfield et al. 2021a. Every genus listed includes native species. We recommend planting native species within these genera when completing restoration projects.

Plant Genus	Common Name	Approximate Bloom Time
		Early / Mid / Late
Cirsium	Native Thistle	
Lupinus	Lupine	
Trifolium	Native Clover	
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	Fleabane/Aster	
Aquilegia	Columbine	
Pedicularis	Lousewort	
Mahonia	Barberry	
Ribes	Currants/Gooseberries	
Arctostaphylos	Manzanita	
Salix	Willow	

Nesting and Overwintering Habitat

- *Preserve undisturbed ground, particularly around areas where rodent activity is observed. Since many bumble bee species depend on ground nesting mammals for nesting habitat, any negative impact to ground nesting mammals will likely also impact bumble bees.*
- *Preserve structural complexity including downed wood, rock piles, moss, leaf litter (both broad leaves and evergreen needles), and native bunch grasses.*
- *Extend land management for bumble bees at least 100 m (110 yd) into habitats (e.g., woodlands and forests) beyond what might traditionally be considered high quality habitat for pollinators (i.e., areas with abundant flowering resources).*
- Generally, bumble bees nest in abandoned rodent burrows, often within forest edge habitat. Based on current knowledge, leaf litter and loose soil are important habitat features for overwintering, and there is some indication that queens may prefer north facing slopes. Given this, land managers should carefully consider the timing of ground disturbance activities.
    - In areas with high quality nesting habitat, avoid ground disturbance activities during summer months.
    - Avoid disturbing potential overwintering sites during winter months.
    - It is possible to survey for nesting sites prior to summer ground disturbance to avoid significant impacts, but surveying for overwintering sites is not feasible given that no effective protocol has been developed.
- If mowing is needed, leave portions of fields unmown to avoid impacting bumble bees nesting on the surface of the ground.
- Avoid applying insecticides and fungicides to potential bumble bee nesting and overwintering habitat and limit the use of herbicides in these areas. If herbicide use is deemed necessary for management of noxious or invasive weeds, apply herbicides outside of the period of adult activity (Figure 2) and take steps to limit drift and impacts on non-target plants. Bumble bees are least active in the winter, generally between November and February.

Find additional resources for assessing, protecting, and restoring foraging, nesting, and overwintering habitat for bumble bees in Appendix D and Appendix E.

Best Management Practices to Mitigate Potential Threats

The following section addresses management practices to mitigate potential threats. Potential threats included in this section are pathogens and competition from managed bees, grazing, fire, pesticides, and climate change. Management actions related to addressing the threat of agriculture, development, and forest management are included in the ‘Applying Best Management Practices Across a Landscape: Management Recommendations by Land Cover Type’ section below. An in-depth discussion of potential threats to bumble bees along with a spatial analysis of threats across Washington state is provided below in the ‘Potential Threats and Forces Shaping Ecosystems’ section.

General Principles

- Whenever possible, minimize impact to high quality bumble bee habitat and set aside undisturbed areas.
- If impacting high quality bumble bee habitat is unavoidable, minimize the impact, and create or restore an equal or greater amount of habitat nearby.
- Maximize habitat connectivity when creating habitat for bumble bees and other pollinators.
- When implementing a treatment of any type (e.g., logging, mowing, burning, grazing), treat no more than one third of an overall site at a time or within a habitat feature (i.e., foraging, overwintering, or nesting habitat).
- Use adaptive management strategies.

Pathogens and Competition from Managed Bees

When considering placing honey bee hives in areas where they will interact with bumble bees, adhere to the following guidelines.

Determine whether rare or declining pollinator species may be present in the area (including all focal species of this conservation strategy). A protocol for surveying for bumble bees is available in Appendix E. We recommend consulting scientists with expertise in pollinator surveys and species identification.

If rare species of bees and butterflies, including threatened or endangered species, special status, sensitive, or other species of concern, are known to exist within the flight area (approximately four miles) where the hives are to be placed, assess potential risks to these populations. See the 'Potential Threats and Forces Shaping Ecosystems' section below for more information about potential risks that honey bees pose to native pollinators. If, after assessment, the land manager feels that apiary placement is consistent with all land management goals, these guidelines will help safeguard bumble bee populations:

- Place apiaries more than four miles from the following, no matter the number of hives:
    - Known locations of pollinators listed on state or federal endangered species acts, or designated as special status, sensitive, or other species of concern (this includes plants with specific and important relationships with native pollinators), including focal bumble bee species highlighted in this conservation strategy (Figure A 1);
    - Wilderness and wilderness study areas, as well as congressionally designated preserves and monuments;
    - Habitats of special value for biodiversity and/or pollinators (e.g., wet meadows, montane and high-elevation meadows).

- Limit each apiary to 20 or fewer hives.
- Separate apiaries by at least four miles.
- Provide land owners and managers with information about the impact of honey bees on native bees, including bumble bees.

Find additional information and resources related to managed honey bees in Appendix D.

Grazing

Implementing conservation grazing practices can reduce negative impacts on bumble bee habitat, for example allowing native plants like these lupine (*Lupinus* sp.) to persist. Photo taken on Bureau of Land Management property east of Goldendale, WA. Photo by the BLM/Greg Shine.

- *Avoid grazing in sensitive areas that provide high quality habitat for pollinators (e.g., alpine meadows, wet meadows, riparian areas).*
- *High-density, short-duration, low animal unit months (AUM), and/or rest-rotation are considered best grazing practices for maintaining habitat for bumble bees.*
- If feasible, adjust grazing time to fall or winter when most flowering plants are dormant and bumble bees are least active. Fall and winter grazing have the least impact on bumble bees; however, soils must be able to withstand late-season or winter grazing, and vegetation must be accessible by livestock.
- For any long-duration grazing allotments (> 45 days), use low intensity grazing to the extent possible (low AUMs for the site).
- *Monitor and adjust utilization rates annually.*
    - *Aim for < 40% in xeric landscapes.*
    - *Reduce or eliminate utilization in riparian areas and mesic meadows and try not to allow stock animals to linger in these habitats longer than necessary.*
    - *Reduce utilization rates during drought years to allow for adequate rest and recovery of the landscape.*
    - *Ideally, move animals throughout a grazing allotment to maintain even utilization throughout the entire area.*
- Consider a rotational grazing scheme for areas/allotments with season-long grazing practices.
- Allow large areas within the allotment to remain ungrazed for an entire year and rotate those areas from year to year.
- As sheep grazing has been shown to be problematic for bumble bee populations, restrict sheep grazing to only after flowering vegetation has senesced.

See the section on grazing in 'Best Management Practices for Pollinators on Western Rangelands' (McKnight et al. 2018) for additional guidance on grazing (available in Appendix D).

Fire

- *Avoid high-intensity fire and work to minimize peak soil temperatures (since nests and overwintering sites are generally below the surface of the ground).*
- Burn in cool, humid conditions to the extent possible.
- *Leave skips and unburned areas as appropriate to maintain habitat diversity.*
- Timing: While there is no perfect time to conduct controlled burns for bumble bees, as burns are likely to affect foraging, nesting, and overwintering habitat, the best time to conduct burns is when bumble bees are dormant (roughly October/November to February, depending on elevation, latitude, and other site-specific factors). This will reduce potential impacts on queen bumble bees during sensitive times of year when they need high quality floral resources to either find a nest or build fat reserves to survive hibernation. No matter the time of year, focus on maintaining a diversity of habitat types and minimizing peak soil temperatures.
- The post-burning period, resulting from either prescribed fire or from wildfire, is an opportunity to introduce additional floral resources.

The period following prescribed fire or wildfire provides an opportunity for introducing additional floral resources to a landscape. Photo taken at the Conboy Lake National Wildlife Refuge near Mt. Adams. Photo by USFWS/Molly Cox.

Pesticides

Reduce Pesticide Risks to Bumble Bees:
Bumble bees could encounter a wide variety of insecticides, fungicides, miticides, and herbicides across their ranges in crop fields and margins, rangeland, forests, and residential and municipal spaces. Pesticide risk is dependent on the toxicity of the pesticides and the level of exposure. Insecticides are often the most harmful pesticides to bumble bees, but many different pesticides can be harmful to survival, reproduction, and other endpoints that affect individual bee health and population growth.

- *Across all land use types, take steps to minimize pesticide use, particularly pesticides known to be harmful to bees and other pollinators.*
    - Implement preventive strategies to avoid or minimize the need for chemical intervention for insects, diseases, and weeds.
    - Use integrated pest or vegetation management to ensure that management is targeted and appropriate for the specific pest based on scouting, monitoring, and a solid understanding of the life history and ecology of the insect pest, disease, or weed species.
    - Consider the full range of management options (e.g., mechanical, cultural, biological, and chemical) to select the most effective, feasible, and low-impact management method for the target pest.
    - Use insecticides only when scouting and monitoring suggest that an insect pest outbreak on crops, rangeland, or forested areas will have economic impacts.
    - When a pesticide application is deemed necessary, select the least toxic pesticide to bumble bees among the available options. Pesticides can be screened for toxicity to bees using the UC IPM Bee Precaution Pesticide Ratings tool, http://www2.ipm.ucanr.edu/beeprecaution/.
    - Do not apply tank mixes of pesticides that jointly increase toxicity to bees. For example, demethylation inhibitor fungicides can greatly increase the toxicity of pyrethroid and neonicotinoid insecticides to bees.
- *Where pesticides are used, minimize potential exposure to bumble bees and their habitat. Take all available steps to avoid off-site movement from pesticide applications.*
    - Do not apply pesticides when pollinators are present, and avoid applying pesticides to or allowing them to drift onto flowering plants.
    - Use targeted applications, such as spot sprays, to reduce pesticide inputs and potential drift.
    - Avoid aerial applications wherever possible.
    - Avoid applications when conditions are more likely to lead to off-site movement of particle or vapor drift, such as high winds or temperature inversions.
    - Calibrate spray equipment annually, and adjust pressure, droplet size, and release height to minimize drift.
- Evaluate and reduce impacts from systemic pesticides.

    - Do not use seed treated with systemic insecticides and avoid applications of systemic insecticides near bumble bee habitat, as these insecticides are highly mobile and can be taken up into the pollen and nectar of flowering plants.
    - Do not plant pollinator habitat in locations where long-lived systemic insecticides (such as neonicotinoids) or persistent herbicides were applied in the previous two years.
- Prioritize sites for habitat restoration that are protected from pesticide drift, runoff, and leaching. Implement spatial or vegetative buffers between pollinator habitat and areas that receive pesticide applications or are planted with pesticide-coated seeds.

Invasive Plant Management:

- Preventing the spread of invasive plant species requires far less effort than eliminating invasive species once they establish—use competitive native plants in restoration and landscaping when practical, and avoid moving soil, hay, or other sources of exotic plant seed long distances. Make sure to thoroughly clean tools and machinery before moving them.
- Consider a variety of methods to control invasive plants (e.g., mechanical, biological, cultural, chemical) and use a targeted approach that minimizes herbicide use.
- Minimize herbicide exposure to bumble bee habitat and non-target plants.
- *Consider a phased approach (no more than one third of a site at a time) to avoid removing an abundance of floral resources all at once. Bumble bees and other pollinators have likely depended on the floral resources provided by invasive plants for several years.*
- *If removed, replace floral resources as soon as possible to avoid local population declines. Create and implement a revegetation plan on a timeline that supports the animals that have depended on invasive plants as a food source.*
- When using herbicides:
    - *Avoid broadcast applications wherever possible, as these are most likely to impact non-target plants and wildlife. Instead, use targeted applications of herbicides, such as spot-spraying, weed wipe, or cut-stump treatments, to minimize off-site movement and impacts to non-target plants.*
    - *Do not spray systemic herbicides on flowering plants in bloom. If applied before a plant senesces, systemic herbicides may reach the nectar and pollen, where they can be consumed by foraging bees. If other treatment methods or timings are not feasible, mow or otherwise mechanically remove flowers before applying herbicides to avoid exposing bumble bees and other pollinators.*
    - *Train staff and/or contractors in plant ID to ensure that only the target plants are treated. Avoid treating native plants, particularly native thistles.*
    - *When available, use selective herbicides targeted toward the invasive plant(s) and avoid using highly persistent herbicides that may hinder germination of native plant species.*

Find additional resources and guidance in Appendix D.

Climate Change

- *Protect and restore natural habitats such as old growth forests, riparian areas, and meadows. Protecting and increasing available habitat are the most crucial steps to increasing climate resilience for bumble bees and other pollinators.*
- Prioritize creating large habitat patches that can support larger bumble bee populations, which are generally less prone to extinction than smaller populations.
- Increase habitat connectivity. Habitat corridors enable range shifts by providing habitat for species to move through to find new habitat. Additionally, increased connectivity allows for larger populations, increased gene flow, and therefore increased genetic variability among populations.
- *Use a variety of climate adapted native plants during restoration projects in order to buffer against the potential impacts of shifting phenology. Native plants are also more likely to adapt to climate variability.*

Planting native plants suited to current and future climate conditions (e.g., drought tolerant plants) will buffer against the impacts of climate change on bumble bees. Photo by the Xerces Society/Kitty Bolte.

Applying Best Management Practices Across a Landscape: Management Recommendations by Land Cover Class

The predominant land cover class varies substantially across level IV ecoregions within Washington (Figure 12, Table B 15). In order to tailor management recommendations to the characteristics of specific areas, we classified medium and high priority ecoregions by land cover class (Dewitz and U.S. Geological Survey 2021). When evaluating management activities within land cover classes it is important to consider the relative value of the habitat for bumble bees. While each type of land cover has the potential to provide foraging, nesting, and overwintering habitat to bumble bees, some land cover classes are generally of higher value to bumble bees than others. The highest value habitat for bumble bees is generally associated with large, natural, undisturbed areas with diverse communities of flowering plants. The bumble bee observations collected as part of the Pacific Northwest Bumble Bee Atlas were most often associated with meadows, which may be present within areas with a variety of land cover designations (Hatfield et al. 2021b). Land cover classes included in this section that likely have the highest value habitat include herbaceous, forest, woody wetland, and shrubland. Other land cover classes, including planted/cultivated and developed areas, have the potential to provide resources for bumble bees if managed appropriately, but given the degree of habitat conversion and impacts to native plant and animal communities, these land cover types are inherently less suitable for bumble bees. Given the variability of habitat within each land cover category, we do not offer a ranking of habitat types in which to prioritize conservation for bumble bees. Instead, we recommend improving, maintaining, and restoring habitat for pollinators across landscapes.

The following recommendations, best management practices, and resources will guide conservation actions aimed to increase the value of a specific parcel of land for bumble bees across a range of land cover classes. Medium and high priority level IV ecoregions with greater than 10% cover by a land cover class are included in the corresponding section below. Additional information available below and in appendices (see references in each section) includes conservation priority, percent cover of that land cover class, and primary potential threats and forces shaping ecosystems. Land cover classes include forest, shrub/scrub, herbaceous, cultivated crops and hay/pasture, development, and woody wetland. Sections are sorted by average percent cover across priority ecoregions from high to low.

The following guidance and best management practices for maintaining, improving, and/or restoring high quality pollinator habitat are derived from currently available peer-reviewed literature. While these recommendations will benefit the eight focal species of this conservation strategy and often a wide variety of other pollinators and invertebrate species, we recommend considering the impact of management actions to all wildlife before implementing them. While each land cover category includes specific management recommendations, you can find additional recommendations, best management practices, and resources in the previous sections, ‘General Management Recommendations’ and ‘Best Management Practices to Mitigate Potential Threats’, and in Appendix D. We recommend implementing best management practices to mitigate potential threats when following management recommendations by land cover type. For example, reducing the impact of pesticides will benefit bumble bees across land cover classifications. Additionally, users should keep in mind that land cover types are often intermixed (e.g., herbaceous meadows within generally forested areas), and therefore combining management recommendations from multiple land cover categories is often required.

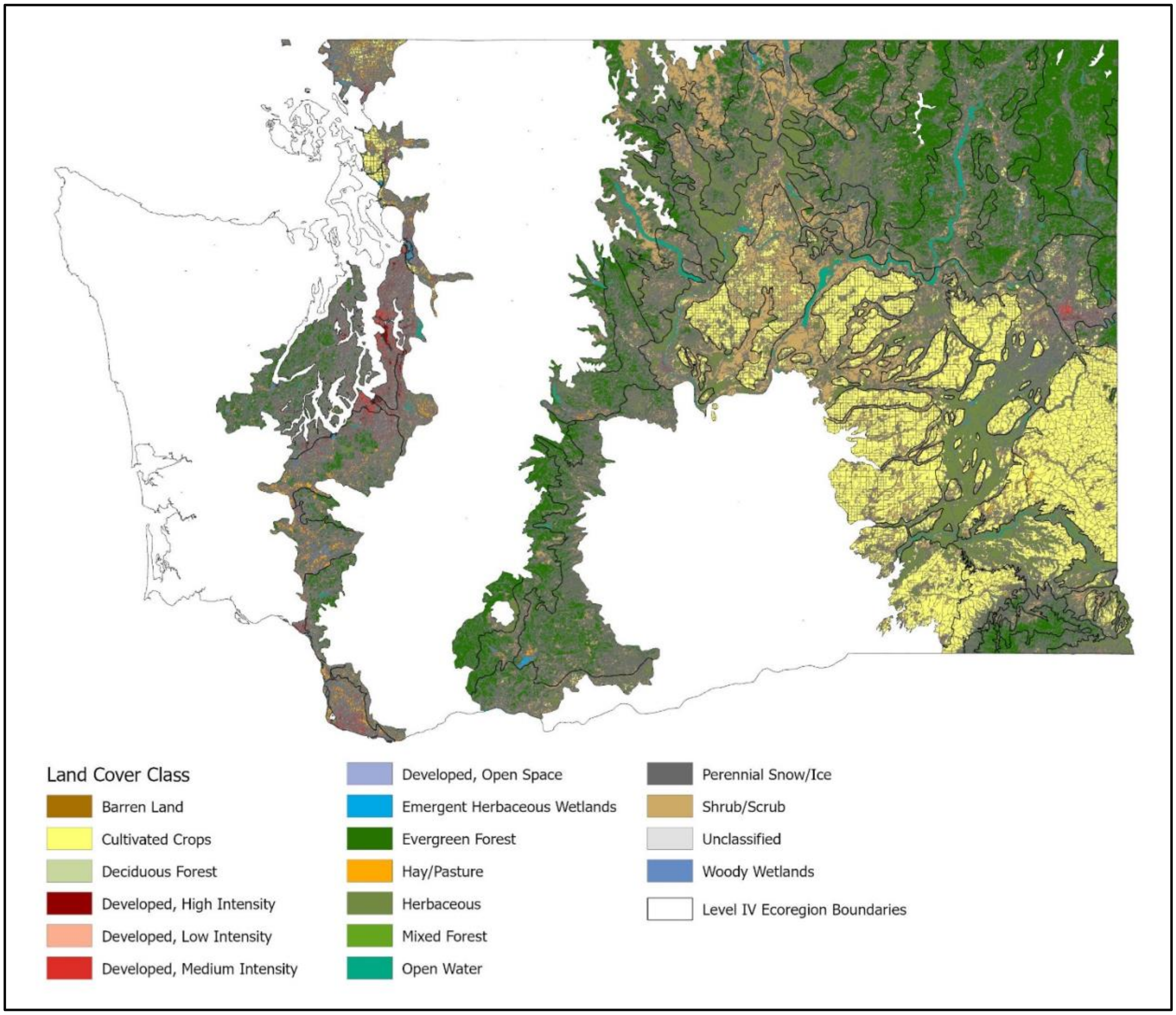
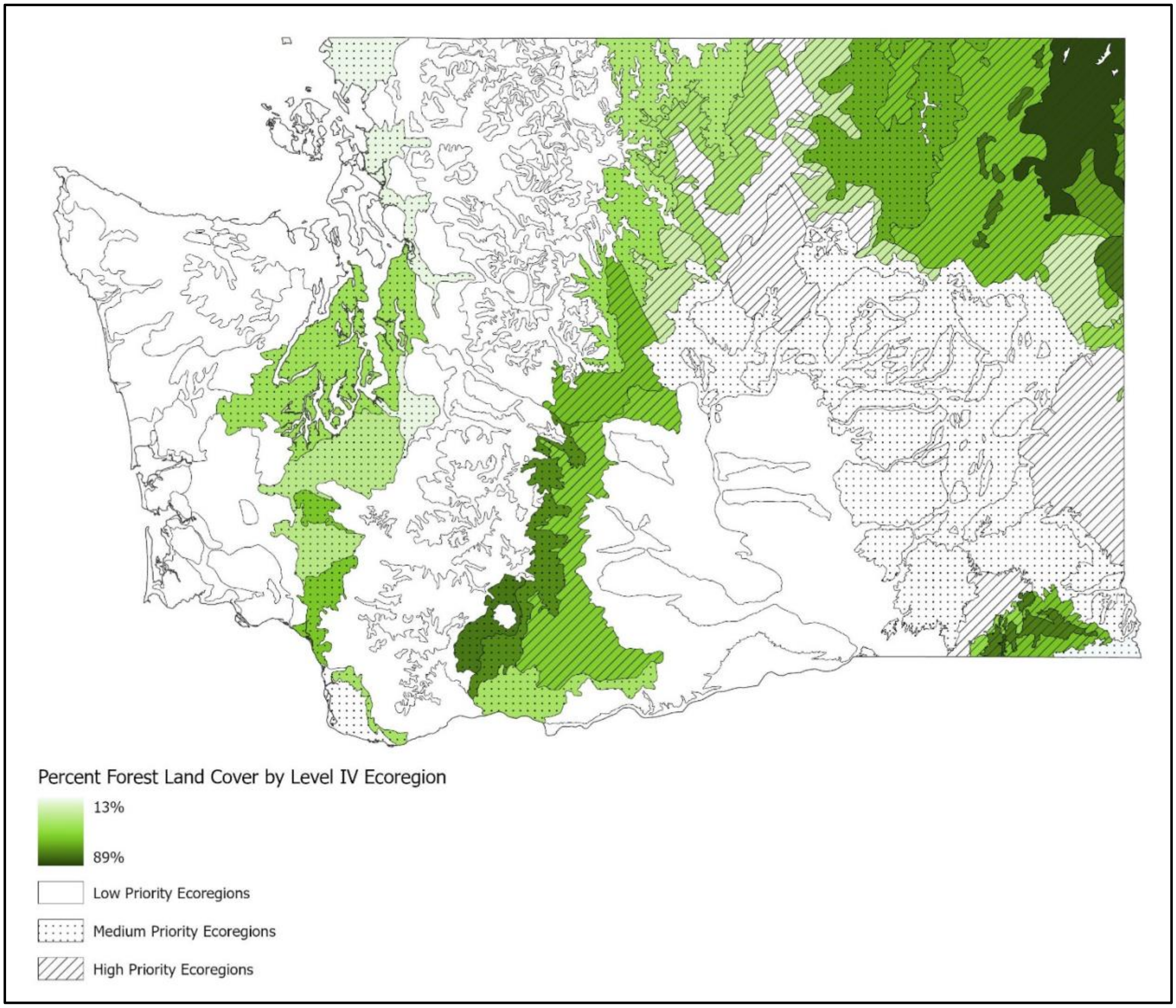


Figure 12. Land cover within level IV ecoregions designated as medium or high priority for conservation.

Forest

Medium and high priority ecoregions containing 10% or greater coverage by forest are generally distributed throughout the Puget Lowlands, east slope of the Cascades and North Cascades, Okanogan Valley and surrounding areas, Selkirk Mountains, and Blue Mountains (Figure 13, Table B 13). The forest land cover category encompasses deciduous, evergreen, and mixed forests. Forest is defined as areas in which trees comprise greater than 20% of total vegetation cover (Dewitz and U.S. Geological Survey 2021).



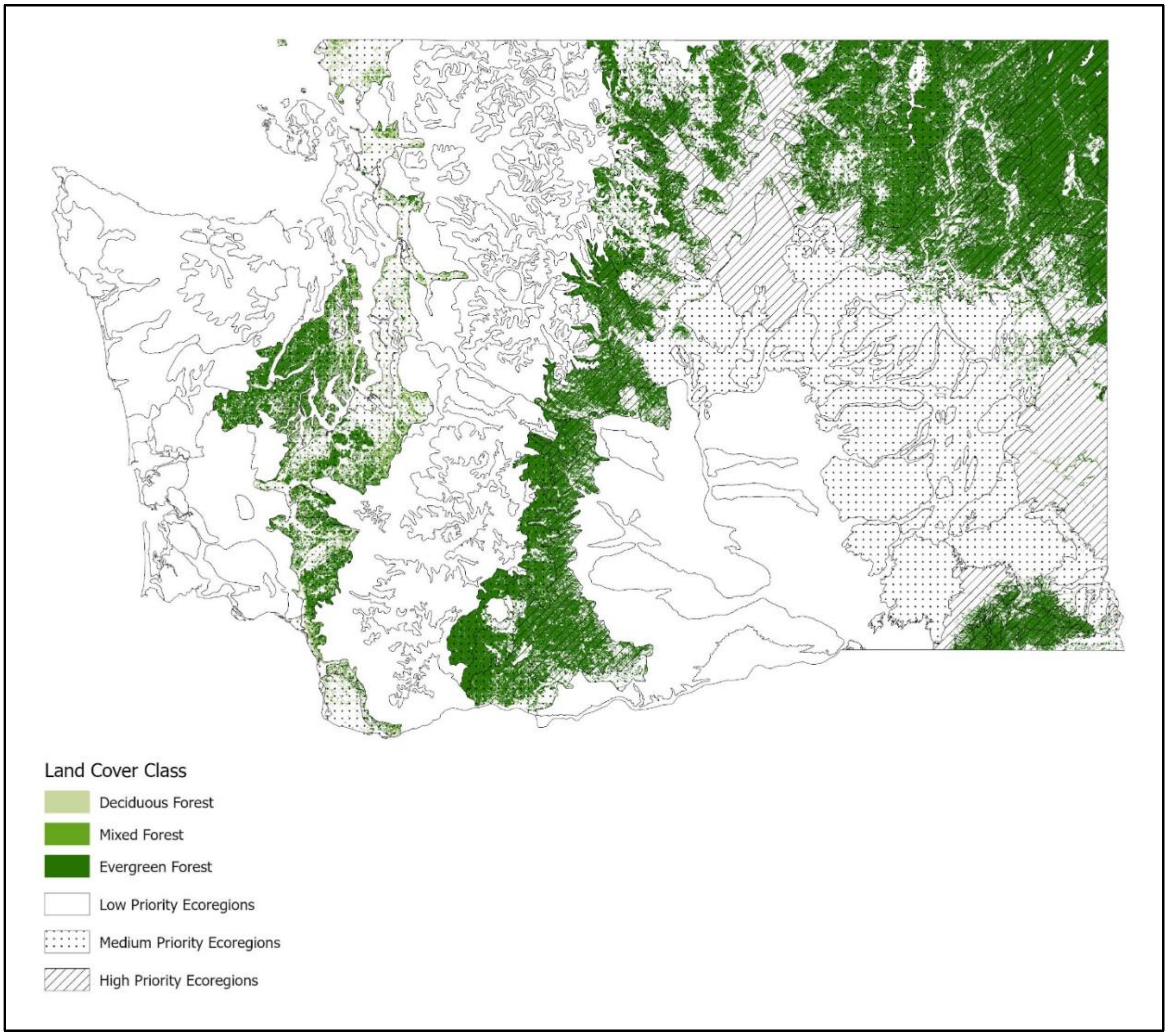


Figure 13. Forest land cover. Above: percent forest land cover within medium and high priority ecoregions in which the land cover is more than 10% forest. Below: forest land cover within medium and high priority ecoregions.

Management Recommendations for Forested Areas

Specific Management Recommendations for Sensitive Bumble Bees:

- Conduct surveys for bumble bee nests before ground disturbing activities, particularly within ten kilometers of known occurrences of focal species (Figure 8), and avoid disturbing ground where bumble bee nests are present. *Prioritize nest surveys in forested areas in close proximity to floral resources, as bumble bees generally nest in areas that reduce foraging flight distances.* Highly stocked, closed canopy forests likely support fewer bumble bee nests than open canopy forests with more diverse understory vegetation.

- If a high number of nests of sensitive bumble bees are found during surveys, map the location of nests and avoid management activities during the flight season in areas near nests (Figure 2). When managing forest areas near bumble bee nests, either through logging or prescribed fire, treat 1/3 or less of the habitat (the mapped area around nests) at a time. This will create more diverse, mosaic ecosystems with a range of habitat for various bumble bee species and life stages.

General Management Recommendations for Bumble Bees:

Note: It is important to consider the wide variety of species relying on forest habitat when implementing management actions. For example, some practices that help pollinators can impact other species such as mollusks (*Reviewed in* Jordan and Black 2012).

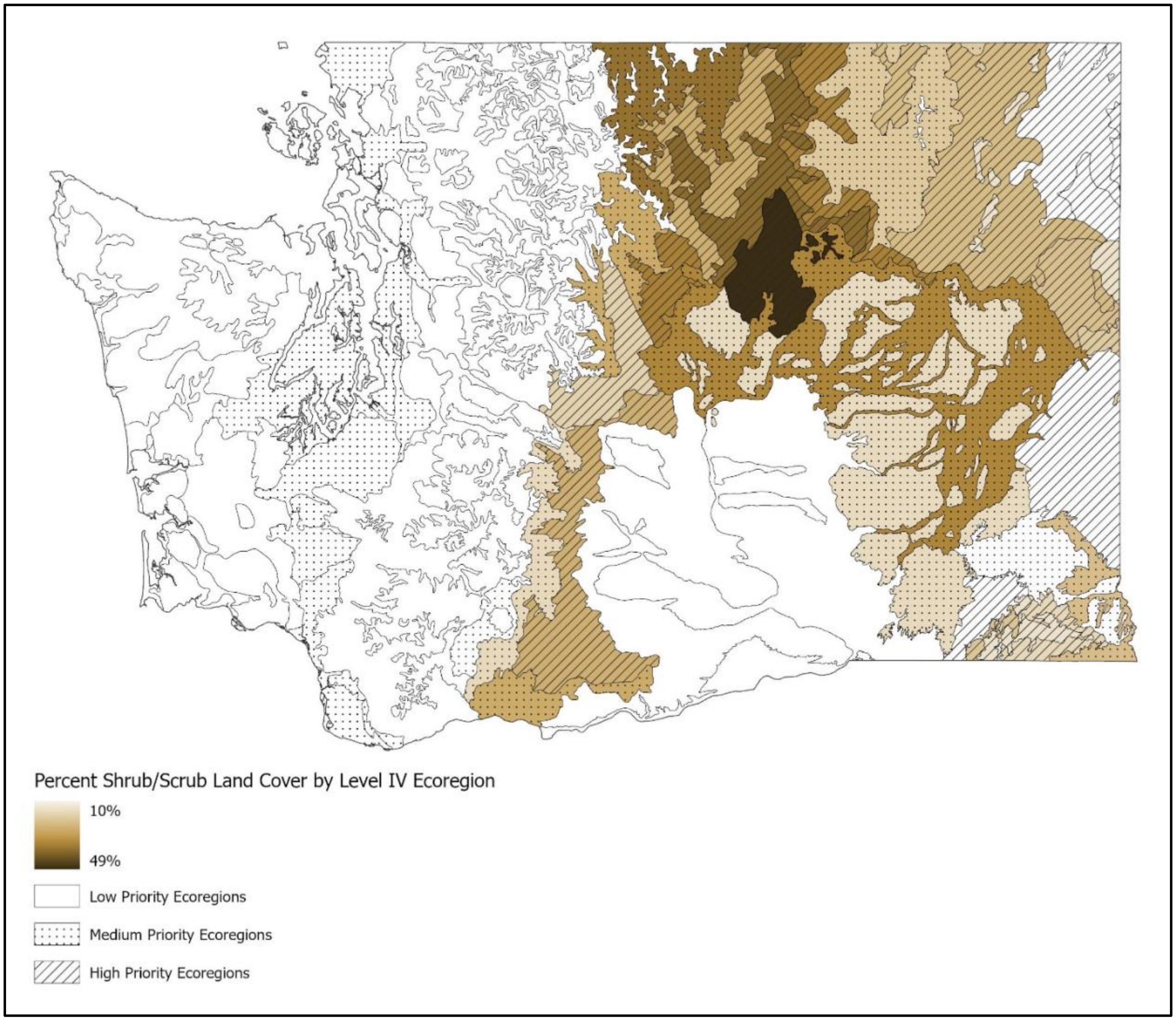
- Prioritize silvicultural practices that create diverse, climate resilient forest ecosystems.
- Identify legacy features in forested areas (e.g., oak, cedar, old growth Douglas fir trees, open meadows, riparian habitat) and implement management actions to support or restore those features. This should inform management actions including timber harvest, prescribed fire, mowing, invasive plant removal, and selection of plant species used in restoration projects.
- *Use prescribed fire and appropriate thinning as a tool to reduce fuel load, thereby decreasing the likelihood of large, high intensity, stand-replacing wildfires and subsequently creating more climate-resilient forests.*
- Selectively thin overstocked stands, particularly of young plantation conifers, to open the canopy, increase solar radiation, and increase herbaceous understory vegetation.
- Selectively thin around valuable trees for wildlife, for example thinning around oak trees will help to restore oak woodland habitat and promote the growth of flowering plants.
- Maintain oak woodlands with prescribed fire and mowing to minimize conifer encroachment and the need for future thinning of conifers.
- *Reduce the use of herbicides, and particularly aerial broadcast spraying of herbicides.* Broadcast application of herbicides will reduce habitat suitability in the target area and potentially in surrounding areas as a result of drift. Commonly used herbicides such as triclopyr and 2,4-D are drift-prone and can easily move off-site to damage non-target plants. Herbicides applied during the growing season will reduce flowering vegetation and subsequent seed set. Consider non-chemical and targeted management options for site preparation to avoid the use of broadcast herbicide applications. If herbicides must be used,

use a targeted approach to minimize drift and impact to the broader vegetative landscape and avoid applying herbicides directly to flowering plants.

- Implement preventive measures to reduce introductions of and movement of invasive species. Scout and monitor to detect and respond to infestations as quickly as possible.
- Use integrated pest management to ensure that management of insect pests and diseases is targeted and appropriate for the specific pest based on scouting, monitoring, predetermined action thresholds, and a comprehensive understanding of its life history and ecology.
- When selecting plants for use in restoration projects, select seeds and seedlings that have not been treated with pesticides.
- Identify planned or ongoing forest treatment projects that pollinator conservation measures could be incorporated into. Examples include invasive plant management, planting native flowering plants, and reducing pesticide application in areas where management includes oak release, thinning, prescribed fire, or other fuel management projects.
- Leave snags and downed woody debris throughout managed forests to create features for nesting and overwintering, while ensuring fuel load is low enough to mitigate the risk of high intensity wildfire. While bumble bees generally do not nest or overwinter in trees, snags provide important habitat for other wildlife including native solidary bees.
- Prioritize maintaining and restoring high quality habitat in forest openings (e.g., meadows) and adjacent forested areas.

Shrubland

Medium and high priority ecoregions containing 10% or greater coverage by shrub/scrub are generally distributed throughout the east slope of the Cascades and North Cascades, in a horseshoe around the Columbia Plateau, and in the Blue Mountains area (Figure 14, Table B 18). Shrub/scrub is defined as areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in early successional stages, and trees stunted from environmental conditions (Dewitz and U.S. Geological Survey 2021).



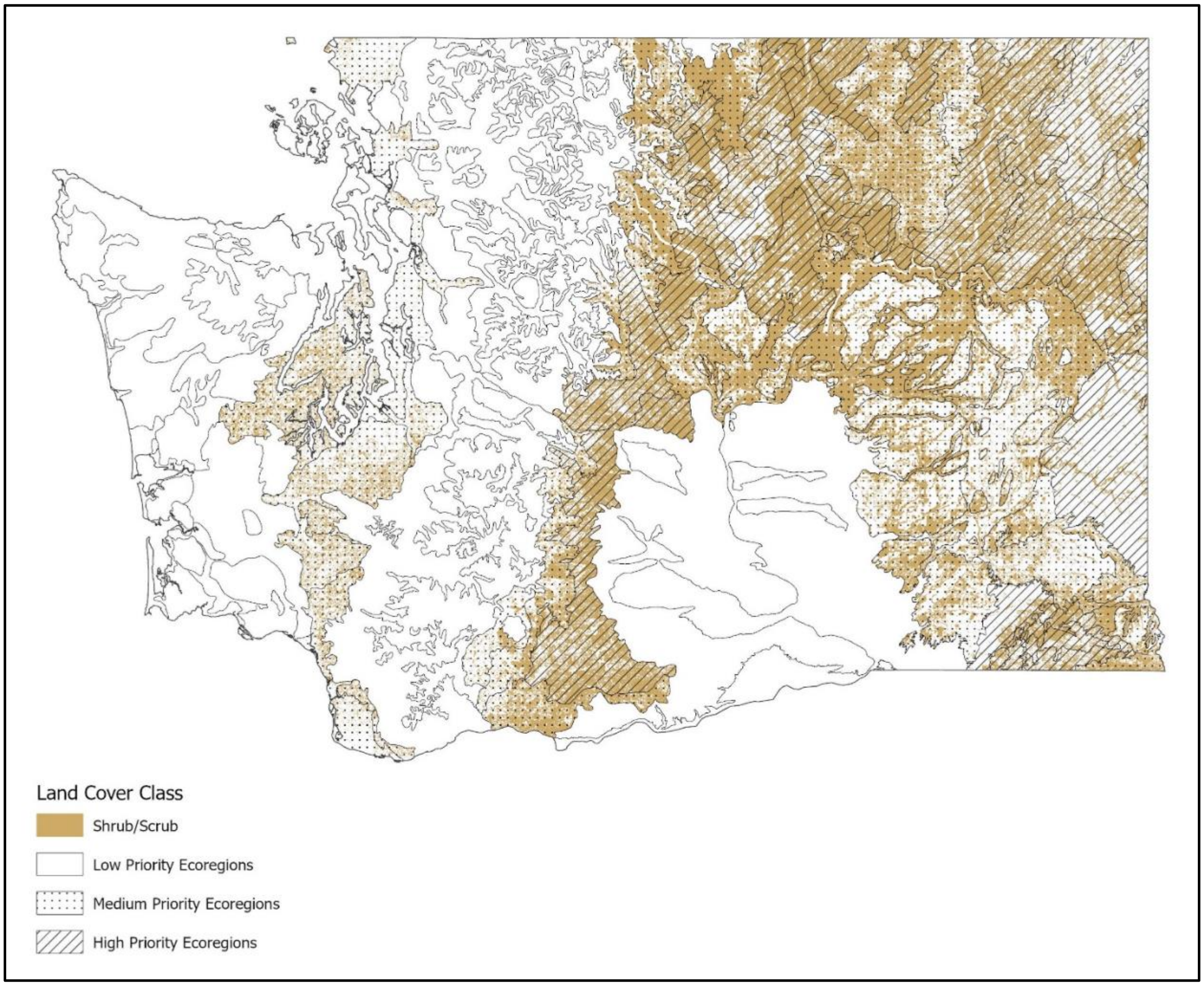


Figure 14. Shrub/scrub land cover. Above: percent shrub/scrub land cover within medium and high priority ecoregions in which the land cover is more than 10% shrub/scrub. Below: shrub/scrub land cover within medium and high priority ecoregions.

Management Recommendations for Shrubland

- Promote locally adapted, native flowering plants that provide foraging resources to bumble bees through reducing negative impacts to existing plant communities and supplementing/restoring degraded communities.
- Avoid fragmentation and conversion of areas that provide high quality habitat for bumble bees. This includes reducing impacts to flowering vegetation and also limiting ground disturbing activities that may harm nesting and overwintering bees.
- *Limit the application of pesticides, particularly the use of broadcast insecticides.* Use integrated pest management to establish action thresholds, scout and monitor for insect

pests, and consider multiple management options. If scouting and monitoring indicate that an insect pest is present at levels that justify the use of a pesticide, and other non-chemical management methods are not feasible, follow best management practices for selecting and applying pesticides to minimize harm to bumble bees. Take all available precautions to minimize drift. *Areas sprayed to control grasshoppers on rangelands often overlap with priority areas for bumble bee conservation. Minimize grasshopper management programs to avoid impacting imperiled bumble bees.* Reducing the use of insecticides in shrub/scrub ecosystems will also benefit other declining species such as sage-grouse, Swainson's hawk, long-billed curlew, and sage thrasher, that rely on grasshoppers for food.

- *Avoid grazing in areas with high abundance and diversity of native flowering plants. If grazing does occur, follow best management practices for grazing.* Over grazing reduces the prevalence of native bunchgrasses, leading to the establishment of non-native grasses (e.g., cheatgrass (*Bromus tectorum*)) which often exclude native flowering plants. The reduction of native bunchgrasses may also impact bumble bees nesting in grass tussocks. Well managed, targeted grazing has the potential to limit the spread of non-native, invasive grasses. McKnight et al. (2018) provides additional information on best management practices for pollinators on western rangelands.
- *Incorporate pollinator plantings, particularly of native flowering shrubs and trees, into stream and riparian restoration projects focused on stream and water table rehabilitation.* See plant lists in Appendix C.
- Where applicable, use prescribed fire and tree removal to control juniper expansion. The dominance of juniper in shrub-steppe ecosystems has the potential to reduce herbaceous plant abundance and diversity, decrease wildlife habitat, and increase the potential for erosion and runoff.
- Incorporate bumble bee conservation actions into existing projects focused on restoring sage grouse habitat (Stiver et al. 2006).

Herbaceous

Medium and high priority ecoregions containing 10% or greater coverage by herbaceous vegetation are generally distributed along the east slope of the Cascades and North Cascades, in a horseshoe around the Columbia Plateau, and Blue Mountains area (Figure 15, Table B 20). Herbaceous is defined as areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but may be utilized for grazing (Dewitz and U.S. Geological Survey 2021).

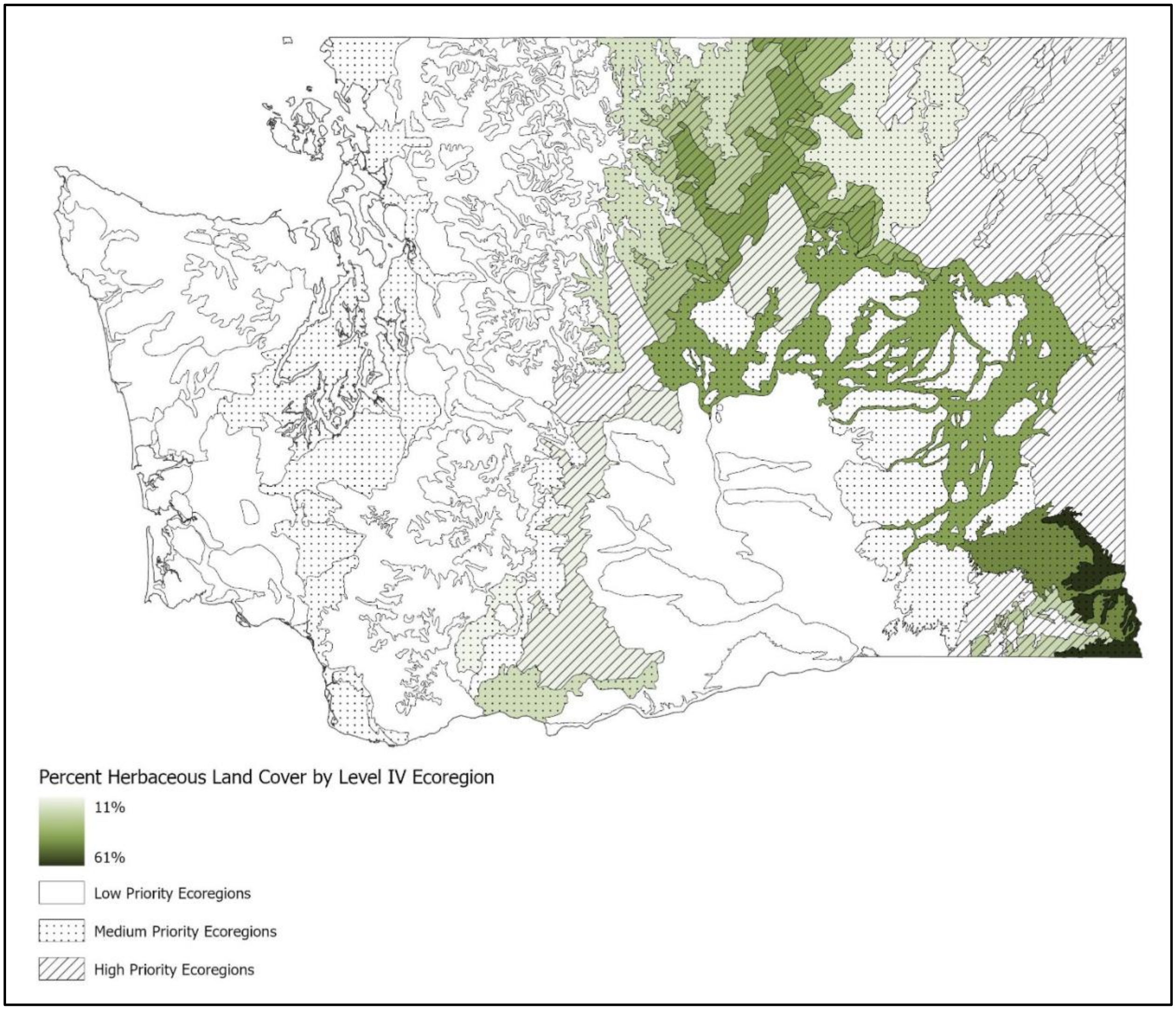


Figure 15. Herbaceous land cover. Above: percent herbaceous land cover within medium and high priority ecoregions in which the land cover is more than 10% herbaceous. Below: herbaceous land cover within medium and high priority ecoregions.

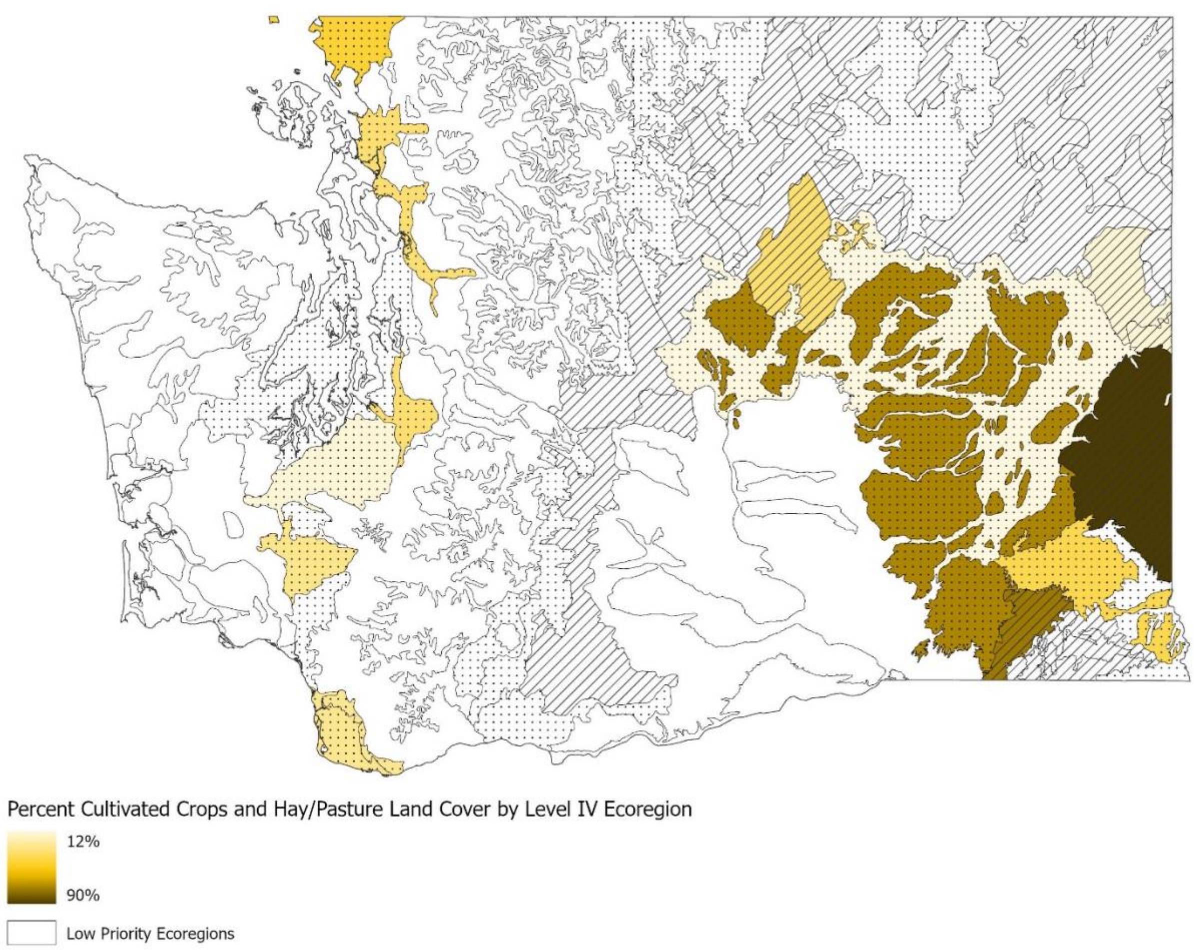
Management Recommendations for Herbaceous Areas

- Promote locally adapted, native flowering plants that provide foraging resources to bumble bees through reducing negative impacts to existing plant communities and supplementing/restoring degraded communities.
- Avoid fragmentation and conversion of areas that provide high quality habitat for bumble bees. This includes reducing impacts to flowering vegetation and also limiting ground disturbing activities that may harm nesting and overwintering bees.
- *Prioritize restoring and maintaining high quality habitat in meadows, as these ecosystems are especially important for bumble bees.*

- *Limit the application of pesticides, particularly the use of broadcast insecticides.* Use integrated pest management to establish action thresholds, scout and monitor for insect pests, and consider multiple management options. If scouting and monitoring indicate that an insect pest is present at levels that justify the use of a pesticide, and other non-chemical management methods are not feasible, follow best management practices for selecting and applying pesticides to minimize harm to bumble bees. Take all available precautions to minimize drift. *Areas sprayed to control grasshoppers on rangelands often overlap with priority areas for bumble bee conservation. Minimize grasshopper management programs to avoid impacting imperiled bumble bees.* Reducing the use of insecticides in shrub/scrub ecosystems will also benefit other declining species such as sage-grouse, Swainson's hawk, long-billed curlew, and sage thrasher, that rely on grasshoppers for food.
- *Avoid grazing in areas with high abundance and diversity of native flowering plants. If grazing does occur, follow best management practices for grazing.* Over grazing reduces the prevalence of native bunchgrasses, leading to the establishment of non-native grasses (e.g., cheatgrass (*Bromus tectorum*)) which often exclude native flowering plants. The reduction of native bunchgrasses may also impact bumble bees nesting in grass tussocks. Well managed, targeted grazing has the potential to limit the spread of non-native, invasive grasses. McKnight et al. (2018) provides additional information on best management practices for pollinators on western rangelands.
- *Incorporate pollinator plantings, particularly of native flowering shrubs and trees, into stream and riparian restoration projects focused on stream and water table rehabilitation.* See plant lists in Appendix C.
- Where applicable, use prescribed fire and tree removal to control juniper expansion. The dominance of juniper in herbaceous areas has the potential to reduce herbaceous plant abundance and diversity, decrease wildlife habitat, and increase the potential for erosion and runoff.

Planted/Cultivated

Medium and high priority ecoregions containing 10% or greater coverage by cultivated crops or hay/pasture are generally distributed in the Puget Lowlands, the Okanogan Drift Hills, and throughout the central and eastern regions of the Columbia Plateau (Figure 16, Table B 22). This category includes the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. This category also includes areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle (Dewitz and U.S. Geological Survey 2021).



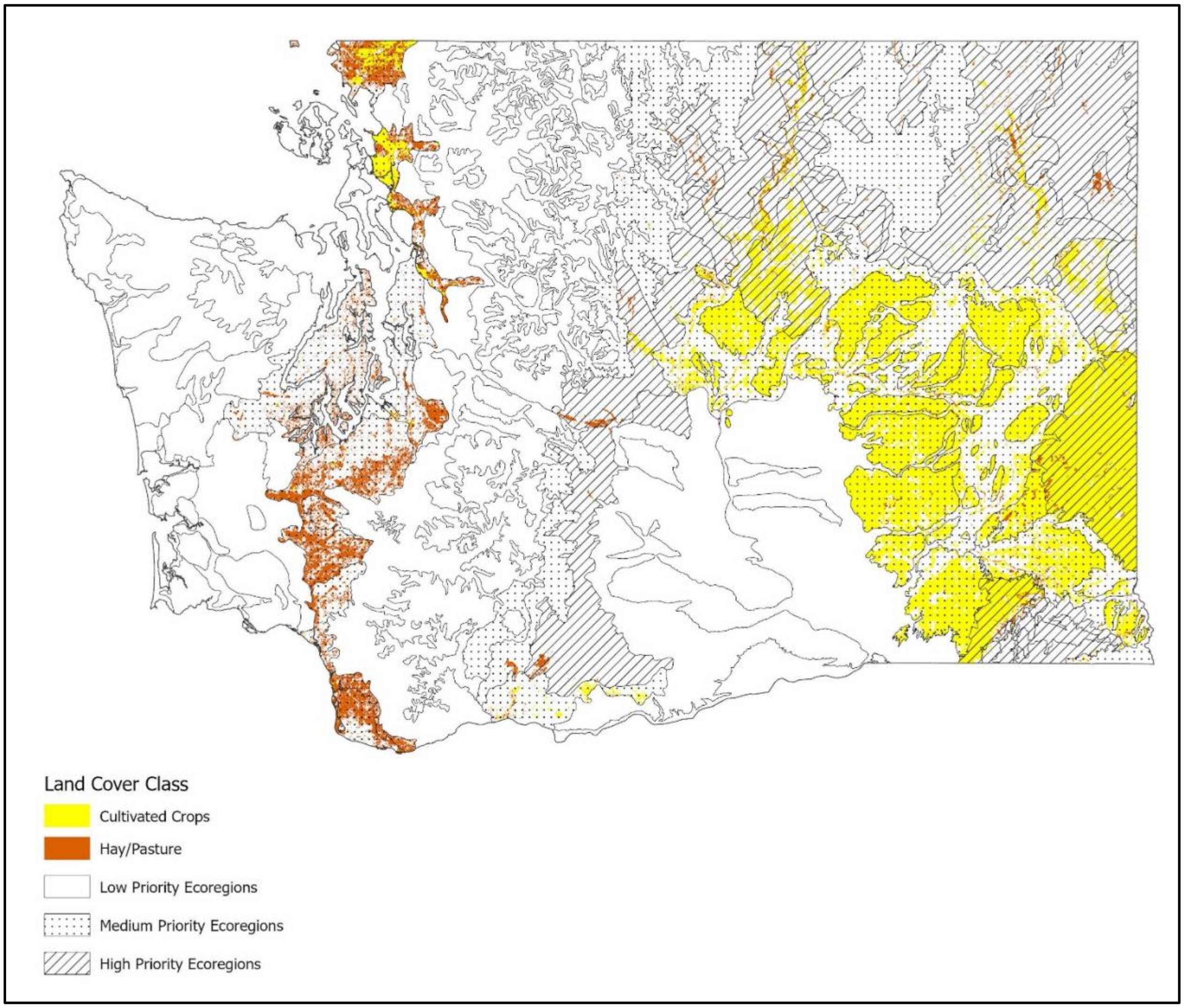


Figure 16. Cultivated crops and hay/pasture land cover. Above: percent cultivated crops and hay/pasture land cover within medium and high priority ecoregions in which the land cover is more than 10% cultivated crops and hay/pasture. Below: cultivated crops and hay/pasture land cover within medium and high priority ecoregions.

Management Recommendations for Planted/Cultivated Areas

- *Take steps to minimize pesticide use, particularly pesticides known to cause harm to bees and other pollinators.*
    - Implement preventive strategies to avoid or minimize the need for chemical intervention for insects, diseases, and weeds.
    - Use integrated pest management to ensure that management is targeted and appropriate for the specific pest based on scouting, monitoring, predetermined action thresholds, and a comprehensive understanding of the life history and ecology

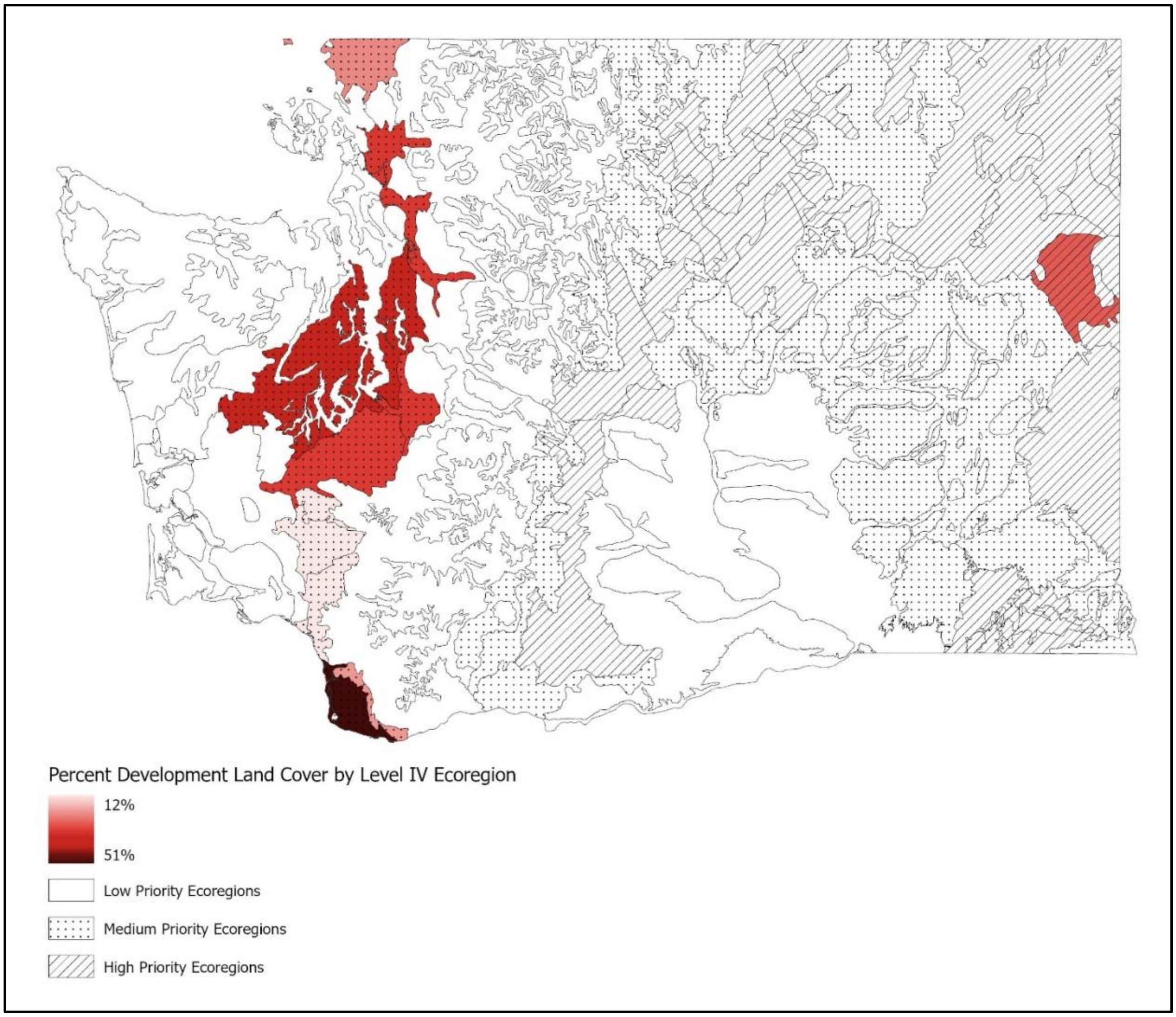
of the insect pest, disease, or weed species.

- *Where pesticides are used, reduce the impacts of applications to bumble bees and their habitat.*
    - Use targeted applications and minimize drift onto flowering plants and into areas where bumble bees may be nesting.
    - Select the pesticide option least toxic to bumble bees and avoid tank mixes of pesticides that may jointly increase toxicity to bees.
    - Evaluate and reduce impacts from systemic pesticides, including treated seeds.
- Increase the diversity of native flowering plants by interseeding with cultivated crops, planting field boundaries, or creating pollinator friendly hedgerows. Implement spatial or vegetative buffers between pollinator habitat and areas that receive pesticide applications or are planted with pesticide-coated seeds.
- Reduce ground disturbing activities including tilling that may impact nesting and overwintering bees.
- *When planting flowering plants, prioritize native, locally adapted plants with overlapping bloom periods throughout the spring, summer, and fall.*
- *If you must mow:*
    - *Mow during the flight season 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. If possible, leave some areas (especially boundaries) entirely unmowed for the full year.*
    - Reduce mowing frequency to allow flowering plants to bloom.
      Avoid mowing during early spring and mid to late summer if there are flowering resources present (this will help protect queen bumble bees at vulnerable life stages).
    - Fall mowing after the first frost is best.
    - *Set the mower at its highest height.*

Find additional resources and guidance in the Best Management Practices to Mitigate Potential Threats section above and in Appendix D.

Development

Medium and high priority ecoregions containing 10% or greater coverage by development are generally distributed throughout the Puget Lowlands and in the area around Spokane (Figure 17, Table B 24). Development types encompass low, medium, and high intensity development and open spaces in developed areas (Dewitz and U.S. Geological Survey 2021). While these categories of development are grouped in this analysis, their potential to provide habitat to bumble bees differs. Generally, the amount and quality of habitat decreases as development density increases.



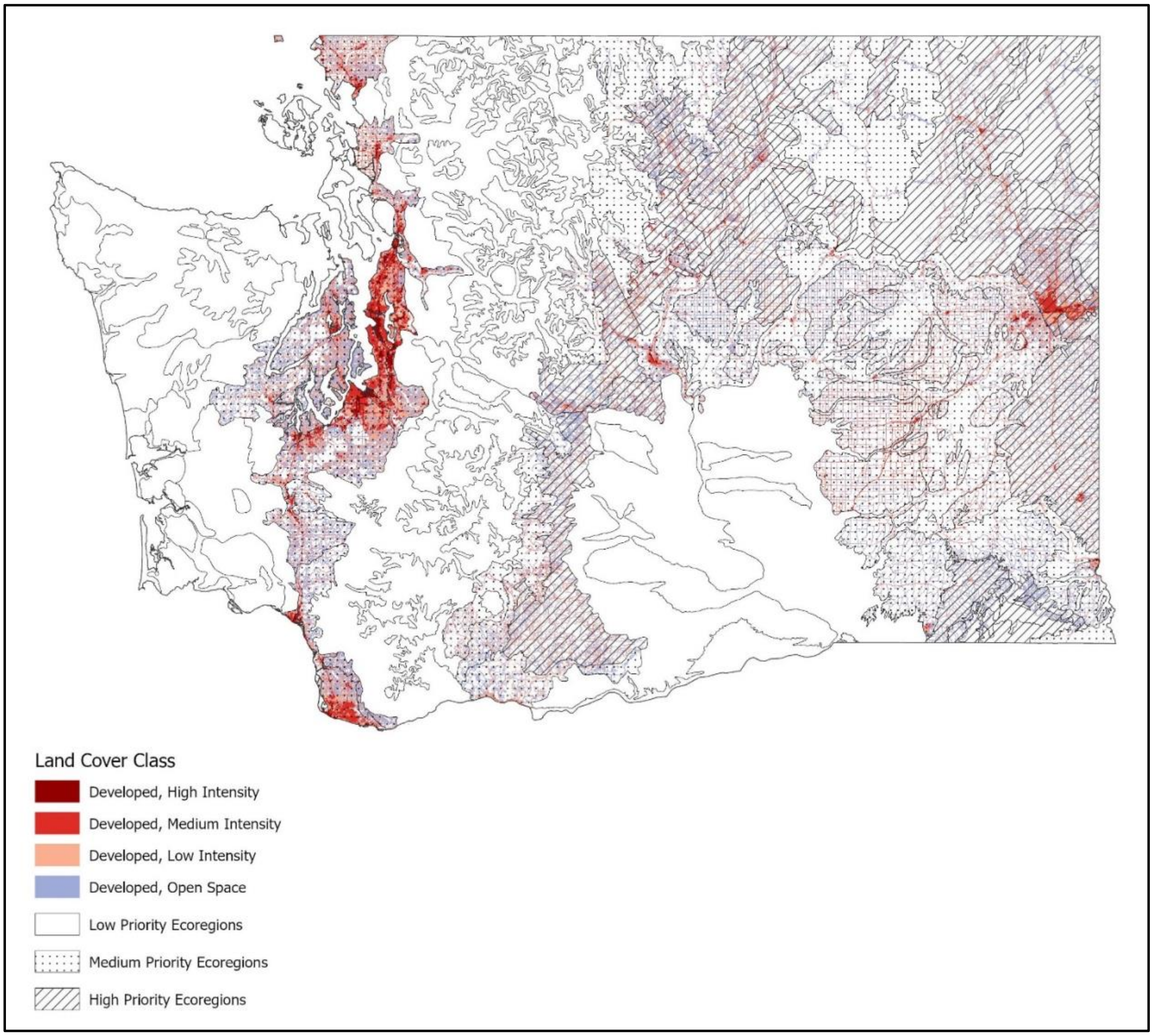


Figure 17. Development land cover. Above: percent development land cover within medium and high priority ecoregions in which the land cover is more than 10% development. Below: development land cover within medium and high priority ecoregions.

Management Recommendations for Development

- *Whenever possible, minimize impact to high quality pollinator habitat and set aside areas (including along roadsides) with the potential to provide significant resources when appropriately managed and/or restored.*
- *Consider landscape context (surrounding habitat providing alternate resources and connectivity to other habitats) when selecting project locations*. Low density development with less than 50% impervious surfaces, including gardens, parks, green spaces, and remnant

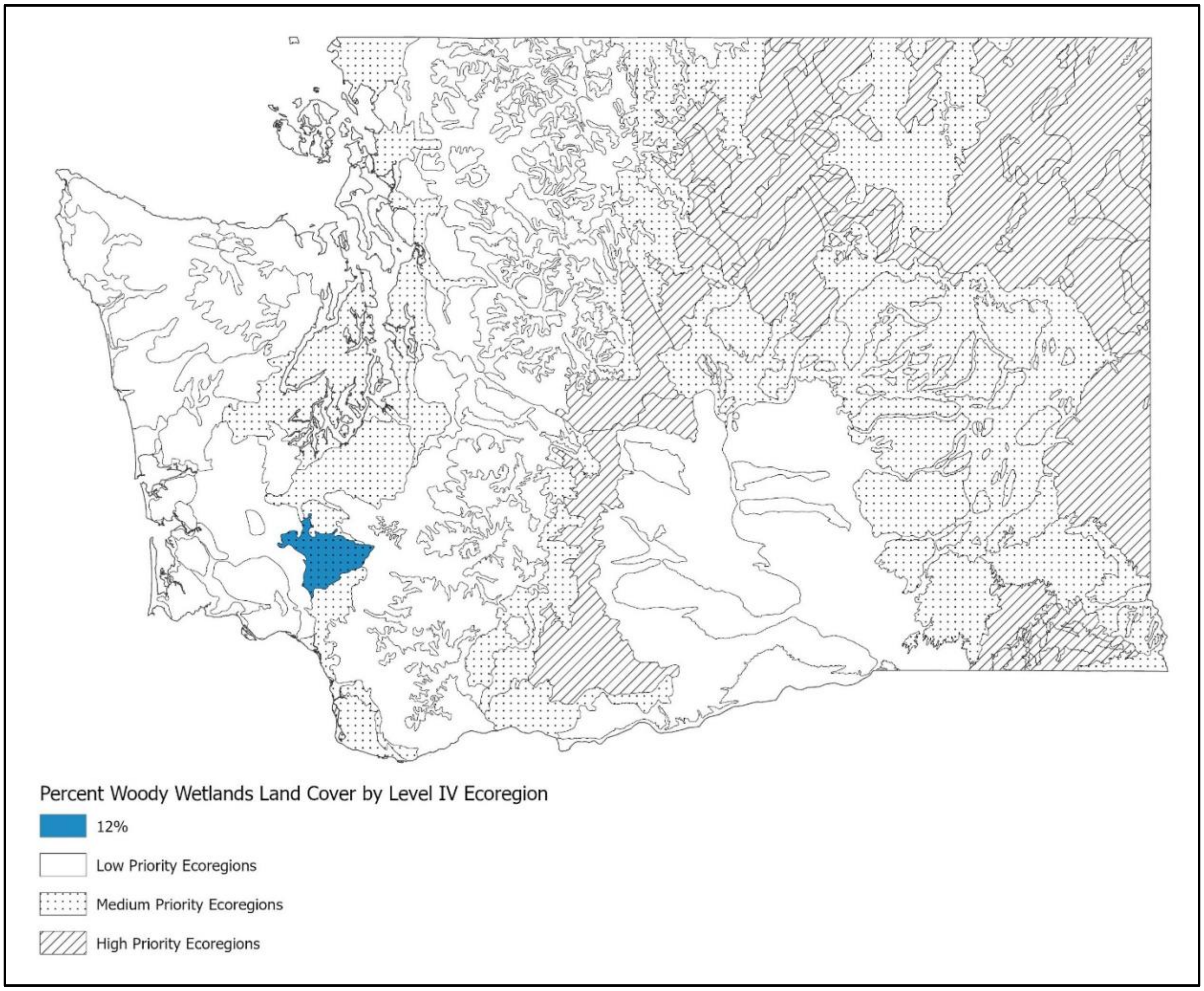
patches of native habitat, generally contain more natural habitat and therefore are more beneficial to pollinators when compared to higher density development. Urban land-sparing (in which development is maximized in certain areas while setting aside others as natural habitat) supports higher total pollinator population sizes compared with land-sharing (in which all lands are developed equally).

- *When landscaping, prioritize locally adapted native plants and avoid pesticide use. Protect areas with flowering plants from pesticides, including from systemic insecticides used for grub control, urban tree pests, and foundation treatments. Ensure that plant materials used for landscaping are free from pesticides that may harm pollinators.*
- Maintain areas of natural, bare ground, for nesting and overwintering.
- Prioritize natural, undisturbed green spaces (e.g., natural parks, native gardens, natural habitat along roadsides) as opposed to managed green spaces (e.g., golf courses, managed lawns). *When incorporating managed green spaces into landscape design, encourage the development of a habitat mosaic, with natural habitat interspersed into more managed habitat. Even relatively small patches of natural habitat, when interspersed throughout developed areas and protected from pesticides, can provide significant benefit to pollinators.* In urban and semi-urban areas, the proportion of the landscape maintained as green space has a direct positive relationship with the prevalence of pollinator communities. Increasing green space will also buffer against climate change impacts by increasing carbon sequestration and reducing the urban heat island effect.
- *Maximize habitat connectivity when creating habitat for bumble bees and other pollinators. Green spaces, including parks and gardens, connecting urban centers to bordering habitat act as corridors that promote urban pollinator diversity. Distributing high quality pollinator habitat through an urban core creates a mosaic of landscape and habitat features, including stepping-stones that allow pollinator species to colonize otherwise inhospitable areas. Roadsides, riparian areas, and rights of way can present excellent opportunities to develop pollinator pathways and increase connectivity.*
- Avoid mowing during early spring and mid to late summer if there are flowering resources present. This will help protect queen bumble bees at vulnerable life stages. Suspending mowing for even a single month in the spring increases bee species richness and abundance.

- Consider increasing the habitat value of areas of primarily managed grass by adding more flowering species. A “bee lawn” may include Dutch white clover (*Trifolium repens*) (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 addition to increasing pollinator habitat, converting lawns to native vegetation can reduce water and pesticide use.

Woody Wetland

The only ecoregion containing 10% or greater coverage by woody wetlands is the Cowlitz/Newaukum Prairie Floodplains located in the Puget Lowlands south of Olympia (Figure 18, Table B 26). Woody wetland is defined as areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water (Dewitz and U.S. Geological Survey 2021).



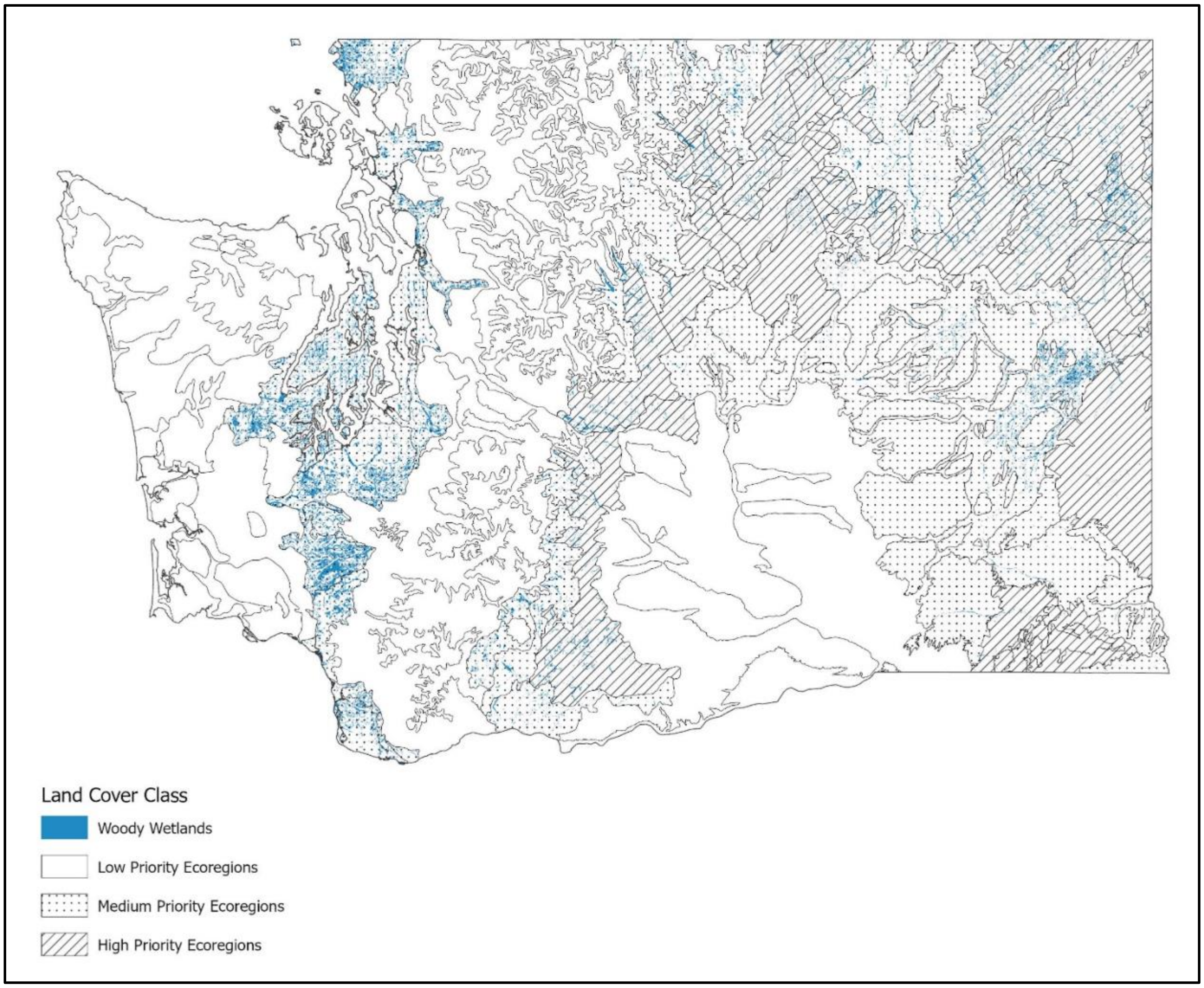


Figure 18. Woody wetland land cover. Above: percent woody wetland land cover within medium and high priority ecoregions in which the land cover is more than 10% woody wetland. Below: woody wetland land cover within medium and high priority ecoregions.

Management Recommendations for Woody Wetland

Note: In addition to woody wetlands, these recommendations apply to riparian areas, wetlands, and wet meadows distributed throughout ecoregions dominated by other types of land cover.

- *Prioritize important riparian restoration species. Some examples that occur broadly across the west include native willow (Salix spp.), rose (Rosa spp.), elderberry (Sambucus spp.), currant (Ribes spp.), and goldenrod (Solidago spp.).*
- When restoring habitat, plant a diversity of flowering species with multiple species blooming throughout the spring, summer, and fall. Diversity of floral morphology is particularly important and is one of the main factors impacting the diversity of pollinators in riparian

habitats.

- Limit the application of pesticides, particularly the use of broadcast insecticides. Reduce the impacts of pesticide application to bumble bees by using targeted applications and minimizing drift onto flowering plants and into areas where bumble bees may be nesting.
- *Where applicable, prioritize ecologically sound mosquito management and avoid the use of adulticides.*
- *Install fences or cages to protect riparian plantings from both native ungulates and livestock until plants are established to the point that they will survive grazing.*
- Avoid placement of apiaries in woody wetlands, which provide essential habitat to pollinators including bumble bees.

Conservation Planning Framework

Below we provide guidance for land owners and managers interested in identifying where to focus resources and what actions in those regions will lead to the most significant positive conservation outcomes for the focal bumble bee species of this strategy. These guidelines can be applied at a variety of scales including state scale long range planning, regional planning, and site-specific planning. While this information is primarily focused on the needs of state and federal agencies, it also applies to other users who own or manage land. We recommend using the interactive online map that accompanies this publication to synthesize spatial information and view maps at a finer scale (access map at: https://xerces.org/publications/strategy-bumble-bee-species-conservation-concern).

- **Focus work on medium or high priority ecoregions**. To do this, identify medium or high priority ecoregions in which your agency manages significant land holdings (consider reach of outreach and education efforts, USFWS Partners program, etc.) (Figure 1, Figure 9, Table 2, Table B 13).
- **Prioritize conservation efforts within 10 km of observations of focal species**. These areas may be within medium and high priority ecoregions or low priority ecoregions (Figure 5, Figure A 1, Table 3).
- **If resources are limited, prioritize conserving areas occupied by the species of highest conservation concern (Table 1)**. Consider which species overlap ecoregions based on SDMs (Table B 2, Table B 3, Table B 4, Table B 5, Table B 6, Table B 7, Table B 8, Table B 9).
- **If narrowing areas to focus conservation work on further would be helpful, consider the number of focal species (Figure 7) and overall trends (Figure 6, Figure 8, Table B 12) in the medium and high priority ecoregions that you identified as having the greatest influence over**. Focusing resources on ecoregions with the most species will provide benefit to a larger number of species while focusing on ecoregions with fewer species will provide the most benefit to those specific species. Priority should be focused on maintaining conditions in ecoregions in which species trends are stable or increasing, while restoration may improve the likelihood of species persistence in ecoregions in which overall trends are negative.

ADAPTIVE MANAGEMENT

The information included in this conservation strategy represents our understanding of the focal species, their status, factors impacting them, and recommended conservation actions at the time when the strategy was written. As more data is collected on these species it is essential that conservation actions are adapted to current conditions and knowledge. This may involve reviewing and revising this conservation strategy. Revisions may include updating information about species, adjusting priority areas, and reevaluating management recommendations and best management practices. Taking steps to continue monitoring efforts and incorporate changing information about imperiled species into management plans aligns with priorities laid out in Washington's State Wildlife Action Plan (WDFW 2015).

Case Study: Scatter Creek Wildlife Area

This case study provides an example of how management practices that benefit bumble bees and other pollinators can be incorporated into projects.

Project Overview and Goals

Scatter Creek Wildlife Area, located in Thurston County western Washington, historically provided oak woodland and prairie habitat to a range of wildlife. Federally threatened species reliant on the habitat include a variety of butterfly species as well as Mazama pocket gophers. Past management practices focused on fire suppression have resulted in conifer encroachment within the wildlife area. Douglas fir (*Pseudotsuga menziesii)* shade out Oregon white oak (*Quercus garryana*) while also increasing fuel loads, resulting in increased wildfire risk. A severe wildfire in the area in 2017 demonstrates the risk of allowing conifers to encroach on oak woodlands.

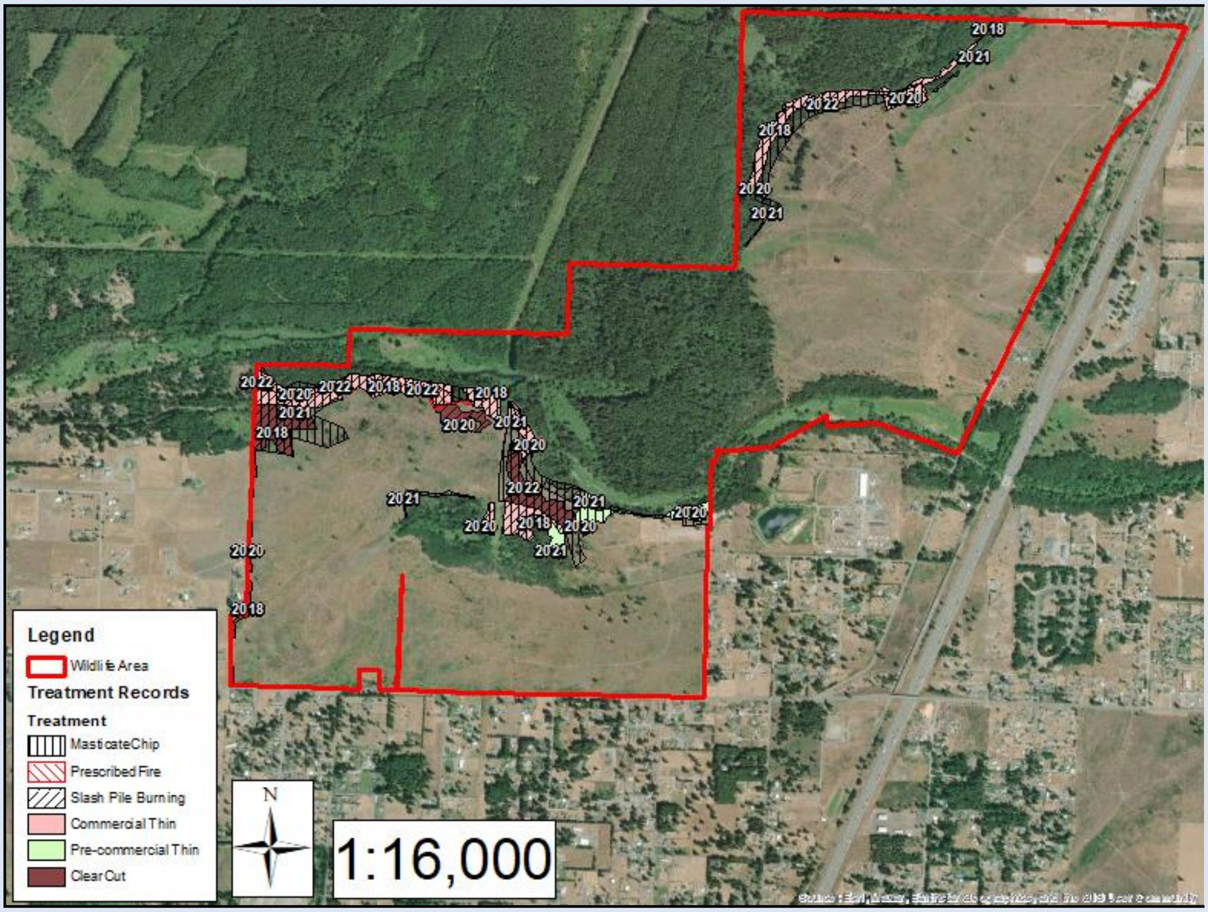
Washington Department of Fish and Wildlife developed a plan to manage Scatter Creek Wildlife Area with the goal of maintaining restored oak woodlands with a combination of prescribed fire, periodic mowing, and thinning. This project was intended to restore habitat essential to the persistence of federally threatened species. Project implementation began in 2018 and has continued through 2022.

Project Impacts to Imperiled Bumble Bees

While this project was not explicitly aimed toward maintaining and restoring habitat for imperiled bumble bees, many of the actions taken have resulted in the restoration of valuable habitat for bumble bees. Using prescribed fire, mowing, and thinning as management tools have the potential to benefit bumble bees in a similar way to the positive impacts to other species; restoring valuable habitat and reducing the likelihood of large, high intensity fires. Additionally, supporting Mazama pocket gophers results in an increased number of rodent burrows, which are frequently used by bumble bees as nesting sites.

While this project benefits imperiled bumble bees in many ways, there are key potential impacts of these management actions to consider and work to mitigate when implementing similar projects. See ‘considerations for future projects’ below for information to help insure that similar projects provide the most benefit to bumble bees.

Site Map



Work Completed

From 2018 through 2022, a variety of management actions have been taken to remove overtopping conifers and encroaching ash trees (*Fraxinus latifolia*) and reduce fuels. These management actions allow treated lands to be managed for rare species associated with prairies and oak woodlands.

In 2018, 5,207 tons of excess biomass was removed from 27 acres of oak woodland and 25 acres of prairie through commercial thinning of conifers. In subsequent years (2020, 2021, and 2022) additional excess biomass was removed through a combination of brush mowing, Oregon ash removal, burning slash piles, and prescribed fire. From 2020 through 2022, 154 acres of oak woodland and prairie were restored.

Before and After Photos


Left: pre-treatment oak woodland/prairie edge. Right: post-treatment oak woodland/prairie edge.


Left: pre-treatment prairie. Right: post-treatment prairie.


Left: pre-treatment non-commercial Oregon oak removal and brush mowing in an oak woodland. Right: Post-treatment non-commercial Oregon oak removal and brush mowing in an oak woodland.

Considerations for Future Projects

- Limit impact to one third of a habitat feature within a site to minimize the impacts to bumble bee populations in the area.
- Prioritize management during times when bumble bees are least active; generally, between November and February.
- Reduce soil compaction when using heavy machinery. Soil compaction may impact nesting and overwintering bumble bees and may reduce soil suitability for native flowering plants.
- Develop a plan to reduce the spread of invasive plant species. This includes cleaning machinery before use to remove transported seeds, reducing soil disturbance, and having a plan for managing invasive plant species (e.g., scotch broom (*Cytisus scoparius*), reed canarygrass (*Phalaris arundinacea L.*), cheat grass (*Bromus tectorum*)) that may colonize the area.
- Plant native flowering plant species that support bumble bees and other pollinators.
- Reduce the impact of management actions to other wildlife present in the area. This includes terrestrial species as well as aquatic species that may be harmed by runoff and changes to water temperature resulting from removal of shade trees.

See the 'General Management Recommendations', 'Best Management Practices to Mitigate Potential Threats', and 'Applying Best Management Practices Across a Landscape: Management Recommendations by Land Cover Type' sections above for additional guidance for developing management plans that provide the most benefit to imperiled bumble bees.

Photo and Map Credit: Washington Department of Fish and Wildlife

POTENTIAL THREATS AND FORCES SHAPING ECOSYSTEMS

Research has shown significant declines in native pollinators globally. These studies indicate that up to 40% of pollinator species may be at risk of extinction as a result of habitat loss and fragmentation, exposure to pesticides, climate change, diseases and pathogens, and competition with non-native species (IPBES 2016). While each of these factors are significant threats alone, the combination of two or more of these factors has likely led to the significant declines observed in North America (Cameron and Sadd 2020). Specific factors likely contributing to bumble bee decline in Washington include: pathogens and competition from managed bees, habitat alterations including grazing, logging, conifer encroachment, agricultural intensification, urban development, fire (both extreme wildfire, and the results of long-term fire suppression on meadow and early seral habitats), exposure to pesticides, climate change, and impacts from reduced genetic diversity. Understanding the relative impact of these factors across species' ranges, while identifying priority areas for conservation, informs on the ground management appropriate to regional conditions and stressors. A brief review of these threats is provided below along with a more in-depth spatial analysis of a subset of these potential threats for which adequate data is available.

While ideally an analysis would incorporate high quality data for all potential threats and forces shaping ecosystems across the entire state, this data does not exist for all factors. We were able to access usable data for the following potential threats and therefore included these in our analysis: agriculture and development, grazing, wildfire, pesticides, and climate change. Potential impacts of pathogens and competition from managed bees, forest management, and genetic factors are not included in this analysis.

In cases where relatively clean data does exist for a potential threat, there are a number of caveats that should be considered when interpreting results. First, depending on the scale and scope of the potential threat, many of these factors can range from a significant threat to a benefit for bumble bees and their habitat. For example, the degree to which fire poses a threat to bumble bees depends on fire intensity, size, timing, and the time horizon for assessing impact. Some fires can cause long-term catastrophic damage, while others may generate beneficial habitat in the near- and long-term. Second, not all potential threats pose the same degree of threat to bumble bees, and not all threats nor how they interact with each other are equally understood. Applying insecticides directly to a site with active bumble bees is an obvious threat. Seasonal grazing, or sublethal exposure to pesticides on the landscape present more nebulous threats that are difficult to measure, especially when combined. Finally, not all available data covers all jurisdictions. For example, while climate change impact can be modeled across the entire state of Washington, data on grazing allotments is generally only available for public lands, and the data available are largely presence/absence rather than quantified threats. The methods section provides an explanation of how potential threats were quantified and how threat categories were delineated.

Geographic Distribution of Combined Potential Threats

The aggregate, or mean, potential threat posed by agriculture and development, grazing, wildfire, pesticides, and climate change in ecoregions designated as medium and high priority is highest in the Cascades, North Cascades, and eastern slopes and foothills of the Cascades including in the Grand Fir Mixed Forest, Chiwaukum Hills and Lowlands, Yakima Plateau and Slopes, Okanogan Highland Dry Forest, and Okanogan Pine/Fir Hills ecoregions (Figure 19, Figure B 1, Table 5). The majority of other medium and high priority ecoregions fall within the medium threat category. Relatively few ecoregions qualify as low threat. The areas with the highest mean potential threat overlap with many of the areas designated as high priority for the conservation of imperiled bumble bees. As noted elsewhere in this document, the trend in mean predicted probability of species presence is generally slightly positive in these ecoregions. This overlap between high priority areas, areas facing the highest mean potential threats, and slight upward trend in mean predicted probability of species presence highlights the importance of working to maintain existing high-quality habitat and mitigate potential threats in high priority ecoregions. In addition to maintaining high quality habitat, improving habitat for bumble bees will positively impact these imperiled species and help to mitigate threats.

Given that the aggregate threat score is a combination of the threat posed by each category of potential threat, these values may be driven by a single threat and may not indicate that all categories of threat pose a substantial threat. Looking at the magnitude and geographic distribution of each potential threat individually will result in a better understanding of the primary forces likely impacting each ecoregion (Table 5). For example, in the Grand Fir Mixed Forest ecoregion, which has the highest potential threat score, potential threats in the high category include wildfire, pesticides, and climate change while grazing poses a medium threat and the threat of agriculture and development is low.

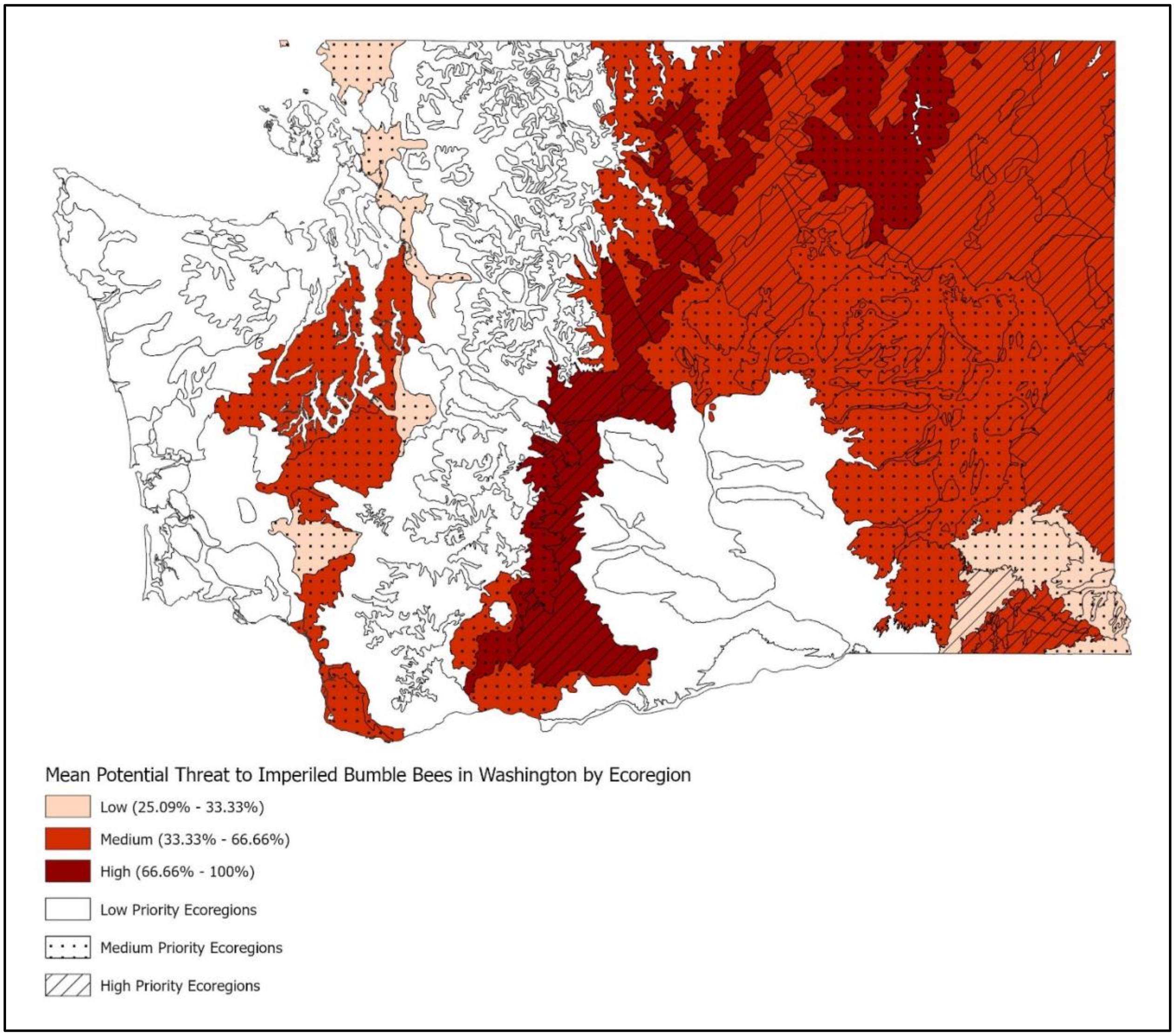


Figure 19. Mean potential threat within level IV ecoregions designated as medium or high priority for conservation. The average potential threat score combines threat scores for agriculture and development, grazing, wildfire, pesticides, and climate change. Find potential threats within all ecoregions in Figure B 1.

Table 5. Potential threats within level IV ecoregions designated as medium or high priority for conservation. Potential threats have been categorized as low (0%-33.33%), medium (33.33%-66.66%), and high (66.66%-100%). This table is sorted by average potential threat score from high to low. Values in the priority column are highlighted, with high priority areas in dark gray and medium priority areas in light gray.

Ecoregion	Priority	Average Potential Threat Score	Agriculture and Development	Grazing	Wildfire	Pesticides	Climate Change
Grand Fir Mixed Forest	Medium	High	Low	Medium	High	High	High
Chiwaukum Hills and Lowlands	High	High	Medium	Medium	High	Low	High

Ecoregion	Priority	Average Potential Threat Score	Agriculture and Development	Grazing	Wildfire	Pesticides	Climate Change
Yakima Plateau and Slopes	High	High	Low	Low	Medium	High	High
Okanogan Highland Dry Forest	Medium	High	Low	High	Low	Low	High
Okanogan Pine/Fir Hills	High	High	Low	High	Low	Medium	High
Chelan Tephra Hills	High	Medium	Low	High	Low	Low	Medium
Canyons and Dissected Highlands	High	Medium	Medium	Medium	Medium	Low	Medium
Wenatchee/Chelan Highlands	Medium	Medium	Low	Low	Medium	Low	High
Channeled Scablands	Medium	Medium	High	Low	Low	Medium	Medium
Selkirk Mountains	High	Medium	Low	Medium	Low	Low	High
Pasayten/Sawtooth Highlands	Medium	Medium	Low	Medium	Low	Medium	Medium
Cascade Crest Montane Forest	Medium	Medium	Low	Low	Low	Medium	High
Mesic Forest Zone	High	Medium	Low	Low	Medium	Low	Medium
Okanogan Valley	High	Medium	Medium	Low	Low	Medium	Medium
Okanogan Drift Hills	High	Medium	High	Low	Low	Low	Medium
Valley Foothills	Medium	Medium	High	Low	Low	Low	Medium
Maritime-Influenced Zone	High	Medium	Medium	Low	Low	Low	Medium
Western Okanogan Semiarid Foothills	High	Medium	Low	Low	Low	Low	Medium
Loess Islands	Medium	Medium	Low	Low	Low	Medium	Medium
Okanogan-Colville Xeric Valleys and Foothills	High	Medium	Low	Low	Low	Low	High
Western Selkirk Maritime Forest	High	Medium	Low	Low	Low	Low	High
Subalpine-Alpine Zone	High	Medium	Low	Low	Medium	Low	Medium
Oak/Conifer Foothills	Medium	Medium	Medium	Low	Low	Low	Medium
Northern Idaho Hills and Low Relief Mountains	High	Medium	Medium	Low	Low	Low	Medium

Ecoregion	Priority	Average Potential Threat Score	Agriculture and Development	Grazing	Wildfire	Pesticides	Climate Change
Spokane Valley Outwash Plains	High	Medium	Medium	Low	Low	Low	Medium
Inland Maritime Foothills and Valleys	High	Medium	Medium	Low	Low	Low	Medium
Cowlitz/Chehalis Foothills	Medium	Medium	Medium	Low	Low	Low	Medium
Portland/Vancouver Basin	Medium	Medium	High	Low	Low	Low	Medium
Southern Puget Prairies	Medium	Medium	Medium	Low	Low	Low	Medium
Palouse Hills	High	Medium	Low	Low	Low	Medium	Medium
Central Puget Lowland	Medium	Medium	Medium	Low	Low	Low	Medium
Cowlitz/Newaukum Prairie Floodplains	Medium	Low	Medium	Low	Low	Low	Medium
Eastern Puget Riverine Lowlands	Medium	Low	Medium	Low	Low	Low	Medium
Lower Snake and Clearwater Canyons	Medium	Low	Low	Low	Low	Low	Medium
Dissected Loess Uplands	Medium	Low	Low	Low	Low	Low	Medium
Canyons and Dissected Uplands	Medium	Low	Low	Low	Low	Low	Medium
Deep Loess Foothills	High	Low	Low	Low	Low	Low	Medium
Fraser Lowland	Medium	Low	Low	Low	Low	Low	Medium

Pathogens and Competition from Managed Bees

Disease transmission between managed and wild bees has been identified as a driver of pollinator declines (Manley et al. 2015). In a range-wide study of eight bumble bee species, the western and American bumble bees, which have both experienced substantial population declines and are focal species in this conservation strategy, were associated with increased levels of the fungal pathogen *Vairimorpha bombi* (previously classified as *Nosema bombi*) relative to species that were found to be stable (Cameron et al. 2011). A recent study investigating the hypothesis developed by Dr. Robbin Thorp, that an exotic strain of *V. bombi* was introduced to North American bumble bees via the commercial bumble bee industry, found that although the pathogen was likely not a novel or exotic strain, commercial bumble bees were likely responsible for spreading and amplifying *V. bombi* throughout North America (Cameron et al. 2016). The commercial use of non-native bumble bee species

(*B. impatiens*) for open field pollination is no longer legal in the state of Washington, however western species including Vosnesensky's bumble bee (*B. vosnesenskii*) and Hunt's bumble bee (*B. huntii*) can be commercially produced in facilities outside of their native ranges, and imported into Washington State for open field pollination. In addition, there are no requirements that non-native commercial bumble bee colonies used for greenhouse pollination in Washington be disposed of after use. If these individuals are released or escape from greenhouses, they may interact with and spread pathogens to native bumble bees. As such, a risk of pathogen spillover from commercial bumble bees in Washington remains. Additionally, *B. impatiens* appears to have become established in parts of Washington due to escape from commercial colonies, and this poses an unknown risk to native species (Looney et al. 2019). Escaped bumble bees in other regions of the world have posed significant threats to native species (Inari et al. 2005, Madjidian et al. 2008, Montalva et al. 2011, Williams et al. 2012, Rosenberger et al. 2021). Pathogens and parasites from other sources (Singh et al. 2010, Koch et al. 2017, Piot et al. 2022), such as RNA viruses from honey bee colonies, also threaten wild bumble bees (Hatfield et al. 2018).

While honey bees are essential pollinators in our agricultural environment, they have been shown to negatively alter native bee and plant communities. Photo by Justin Wheeler.

While honey bees are essential pollinators in our agricultural environment, their influence on native ecosystems is generally negative (*reviewed in* Hatfield et al. 2018). The majority of research examining the effects of honey bees on wild bee and plant communities suggest that honey bees can negatively alter plant and native bee communities through their degree of resource (pollen and nectar) removal (Paton 1996, Mallick and Driessen 2009, Shavit et al. 2009), potential to competitively exclude native bees, forcing them to switch to other, less abundant, and less rewarding plant species (Wratt 1968, Eickwort and Ginsberg 1980, Pleasants 1981, Ginsberg 1983, Paton 1993, 1996, Buchmann et al. 1996, Horskins and Turner 1999, Dupont et al. 2004, Thomson 2004, Walther-Hellwig et al. 2006, Tepedino et al. 2007, Roubik 2009, Shavit et al. 2009, Hudewenz and Klein 2013, Rogers et al. 2013), and relatively high pathogen loads (Singh et al. 2010, Fürst et al. 2014).

In Washington state, impacts from managed honey bees on public lands is likely minimal. There are two active apiary permits on Forest Service lands, none on Bureau of Land Management lands, and one on Washington Department of Fish and Wildlife lands. Pathogens and competition from managed bees likely result primarily from managed bees on private land.

Agriculture

Additional habitat alterations, including agricultural intensification (Williams 1986, Carvell et al. 2006, Diekötter et al. 2006, Fitzpatrick et al. 2007, Kosior et al. 2007, Goulson et al. 2008) may threaten a range of bumble bee species. Since the middle of the twentieth century, the growing population and implementation of industrial farming techniques have resulted in large areas of North America being managed as intensive agricultural lands. The conversion of natural areas to monoculture has removed prime habitat for bumble bees, severely limiting habitat availability and restricting species to smaller, more fragmented areas. Since bumble bees generally nest and overwinter under the ground or on the ground surface, any ground disturbance associated with agriculture, including plowing and mowing, can destroy nesting and overwintering sites, as well as suitable habitat.

Pesticide applications associated with agriculture also negatively impact bumble bees and the resources on which they rely. Flowering plants, soil, and surface waters in agricultural landscapes are commonly contaminated with complex mixtures of agrochemicals, which can have a range of impacts to bumble bee survival, reproduction, behavior, and other endpoints that could affect individual and colony health as well as overall population growth (Whitehorn et al. 2012, Goulson et al. 2015, Botias et al. 2016, Main et al. 2020, Siviter et al. 2021a, Siviter et al. 2021b). A recent analysis of factors contributing to the decline of the western bumble bee (*B. occidentalis*) found that the intensity of agricultural use of nitroguanidine neonicotinoid insecticides was among the top stressors associated with lower occupancy of *B. occidentalis* across its range (Janousek et al. 2023).

Development

Similarly, urban development has been associated with declines in bumble bee diversity and abundance (Bhattacharya et al. 2003, Jha and Kremen 2013, Glaum et al. 2017). Conversion of natural habitat to impermeable surfaces 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, and non-native ornamental plants. The breeding process for ornamental plants often leads to a reduction in the quantity and/or quality of pollen and nectar, or loss of pollen and nectar altogether. Additionally, pesticides are applied in urban settings, often above recommended levels, to control unwanted species in lawns, gardens, and other landscaped areas. While bumble bees can forage and disperse over relatively long distances, isolated habitat patches created by the combination of agriculture and development are unlikely to provide a sufficient long-term solution to habitat fragmentation (Goulson et al. 2008, Goulson 2010, Cameron et al. 2011). Like many other potential threats, urban areas have the potential to provide habitat for bumble bees and other pollinators when managed appropriately.

Agriculture and development are predicted to have the most substantial impact within the Columbia Plateau in the Channeled Scablands, Okanogan Drift Hills, Valley Foothills, and Portland/Vancouver Basin ecoregions (Figure 20). Areas with a medium potential for change resulting from agriculture and development include the majority of the Puget Lowlands, the Chiwaukum Hills and Lowlands, an ecoregion on the eastern slope of the Cascades just north of highway 90, areas around the Okanagan Valley and Spokane, regions of the Columbia Plateau, and areas located near the Blue Mountains in southeastern Washington.

This analysis indicates areas most at risk for change resulting from agriculture and development. This does not necessarily mean that land cover in these ecoregions is currently substantially composed of agriculture and/or development. Some of these areas may already be substantially impacted, for example the Puget lowlands around Olympia, Tacoma, and Seattle, while others may currently have minimal impact from agriculture and development. Users should exercise caution when interpreting the results of this analysis given that it combines the potential threats posed by agriculture and development; two land uses with varying impacts on pollinators directly and on the habitat on which they rely.

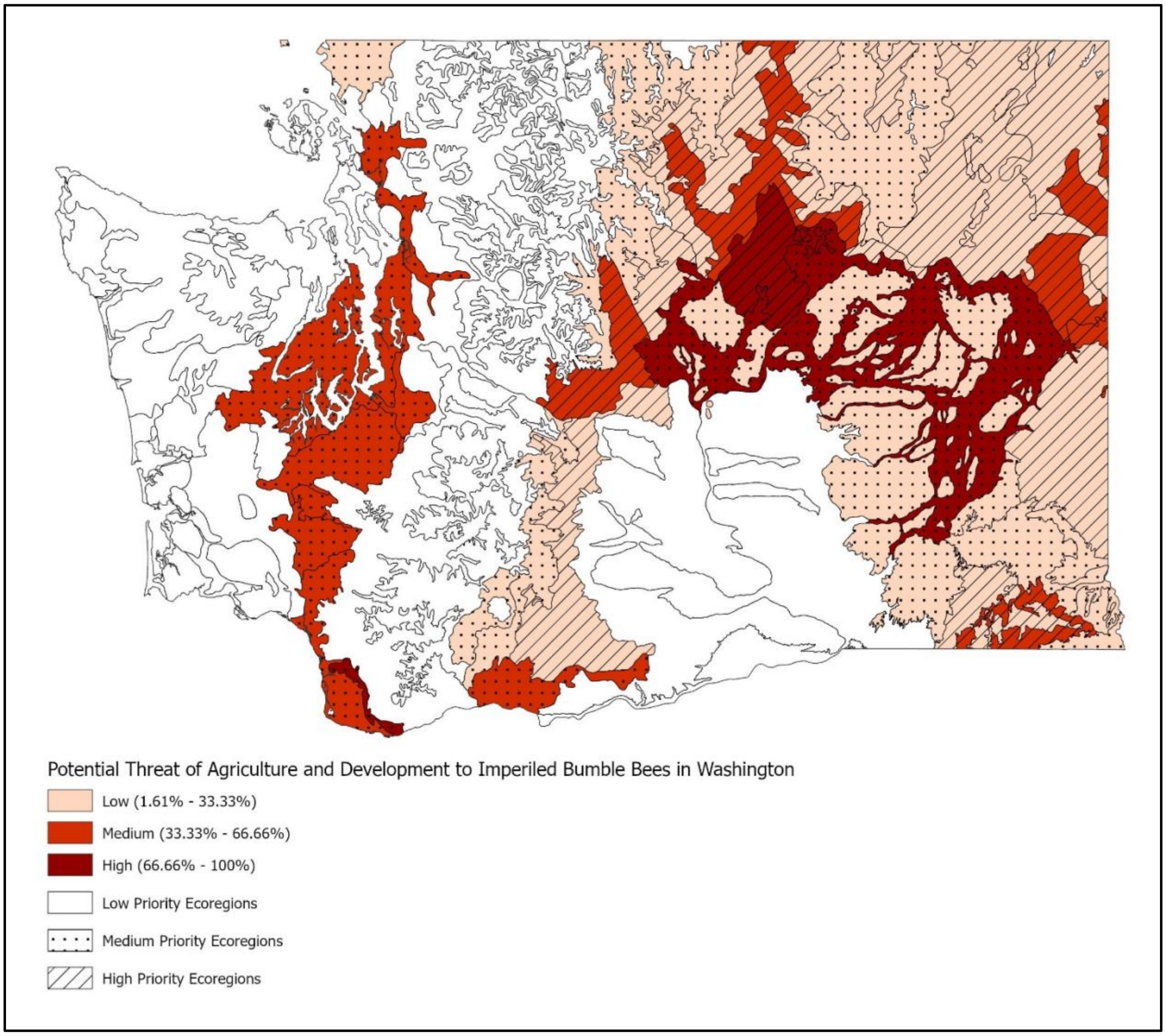


Figure 20. The potential threat of agriculture and development within level IV ecoregions designated as medium or high priority for conservation.

Grazing

Overgrazing by livestock can be particularly harmful to bumble bees (*reviewed in* Hatfield et al. 2012) by removing floral resources, especially during the mid-summer period when flowers may already be scarce (Hatfield and LeBuhn 2007). In addition, grazing can also alter hydrology and soils, increasing bare ground, erosion, and compaction (DeBano 2009, Schmalz et al. 2013). Livestock may trample nesting and overwintering sites, or disrupt rodent populations, which can indirectly harm bumble bees. Poorly managed grazing can severely degrade ecosystems (Bilotta et al. 2007) by substantially altering the structure, diversity, and growth habits of plant communities and associated insect communities (Kruess and Tscharntke 2002a, DeBano 2006, 2009, Zhu et al. 2012). Livestock grazing can alter plant communities by reducing biomass, selecting for or against plant species, changing the plant community structure (physical structure and species composition), and by affecting the reproductive capacity of plants (e.g., seed production and dispersal). Grazing systems that remove a high level of forage, have livestock in a given pasture for extended periods of time, and do not provide long rest periods can shift plant communities towards invasive plants that are both less palatable to ungulates and provide less suitable habitat for native pollinators (Vavra et al. 2007, Knight et al. 2009, Hanula et al. 2016). For example, grazing often leads to an increase in invasive grass species and reduced tussock forming perennial native grasses, which may decrease available nesting and overwintering sites for bumble bees.


Overgrazing can result in reduced floral resources, increased invasive grasses, and altered hydrology and soils. Photo by the BLM/Greg Shine.

Generally, as the intensity of livestock grazing increases, pollinators, including butterflies, moths, and other insects, decline in abundance and/or diversity (Morris 1967, Hutchinson and King 1980, Sugden 1985, Dana 1997, Balmer and Erhardt 2000, Cagnolo et al. 2002, Carvell 2002, Kruess and Tscharntke 2002a, 2002b, Pöyry et al. 2006, Vulliamy et al. 2006, Sjödin 2007, Littlewood 2008, Jerrentrup et al. 2014, Elwell et al. 2016). If managed appropriately, grazing has the potential to improve habitat for pollinators by maintaining heterogenous and open herbaceous forb-dominated plant communities, allowing growth of spring and summer flowering plants (Murphy and Weiss 1988, Elligsen et al. 1997, Smallidge and Leopold 1997, Weiss 1999, DeVries and Raemakers 2001, Pöyry et al. 2004, Pöyry et al. 2005, Saarinen et al. 2005, Rundlöf et al. 2008, Potts et al. 2009, Vanbergen et al. 2014), and in some specific circumstances, suppressing noxious or invasive plants (Weiss 1999, Schmelzer et al. 2014), but this requires a high degree of active and adaptive grazing management.

The potential threat posed by grazing, determined based on acres of BLM and USFS active and historic grazing allotments on public land, is greatest in the Okanogan Highland Dry Forest, Okanogan Pine/Fir Hills, and Chelan Tephra Hills ecoregions (Figure 21). Grazing poses a medium threat in the Grand Fir Mixed Forest, Selkirk Mountains, Pasayten/Sawtooth Highlands, Chiwakum Hills and Lowlands, and in the Canyons and Dissected Highlands ecoregions. While this analysis provides a general overview of where grazing has occurred both historically and recently, land managers may find it useful to see the geographic extent of allotments, their status (active, vacant, or closed), and time period. This information is available in the accompanying interactive online map (https://xerces.org/publications/strategy-bumble-bee-species-conservation-concern). Grazing on Washington Department of Fish and Wildlife land is fairly minimal and therefore was not included in this analysis, however information on these allotments is included in the online map.

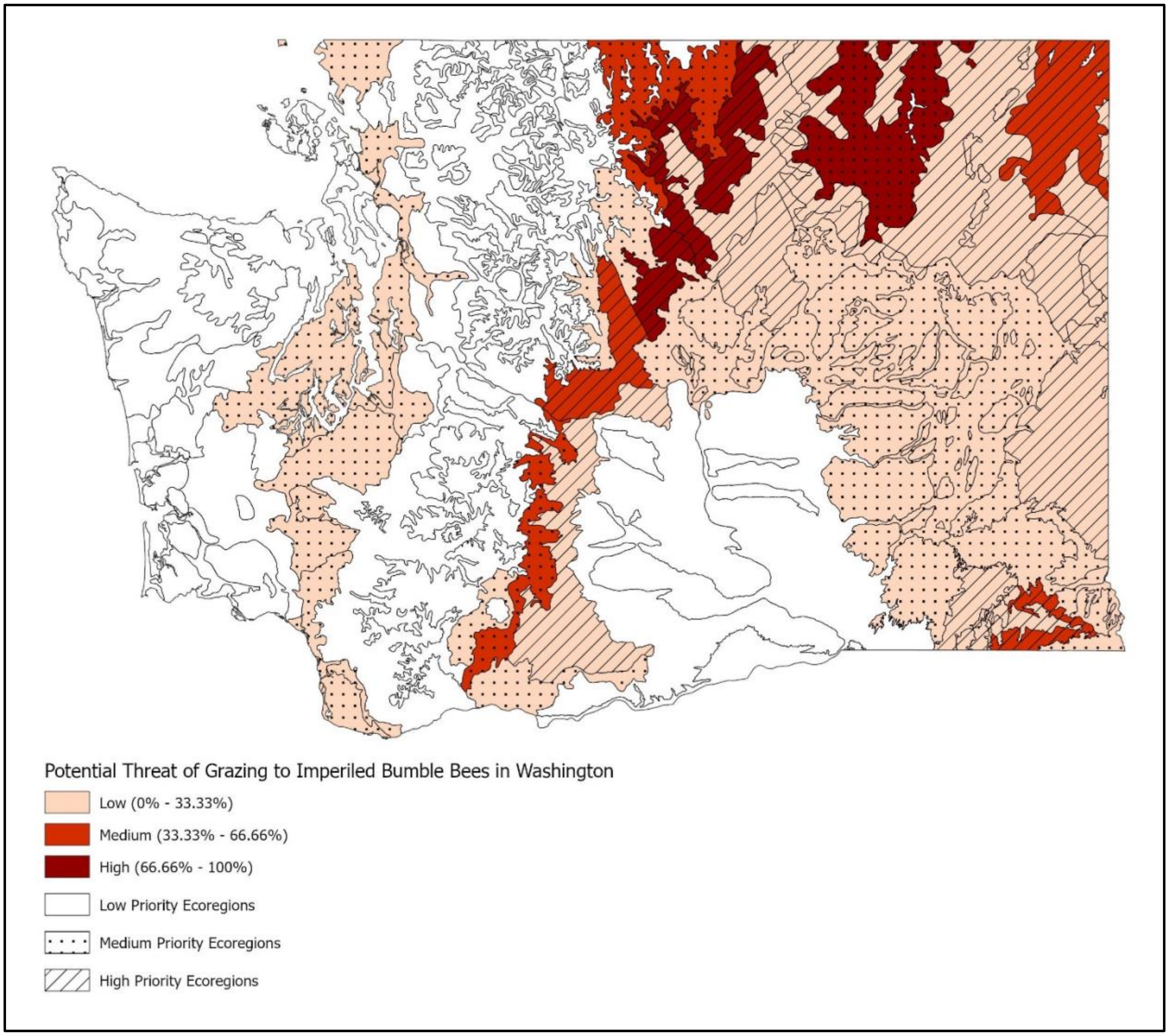


Figure 21. The potential threat of public lands grazing within level IV ecoregions designated as medium or high priority for conservation.

Forest Management

Logging is another common management activity in the state of Washington with varied implications for bumble bees. While forests are not generally associated with foraging bumble bees (Figure 3), they often provide important foraging habitat early in the season due to their high density of early-flowering plant species (Inari et al. 2012, Wray et al. 2014, Kämper et al. 2016, Mola et al. 2021), and likely provide both nesting and overwintering habitat. Logging has the potential to cause ground disturbance, impacting nesting and overwintering resources, and often leading to the colonization of invasive plant species. If managed appropriately, logging has the potential to positively impact bumble bees by opening the canopy, creating corridors, increasing solar radiation, and therefore leading to increased herbaceous understory vegetation, along with the nesting and overwintering habitat they provide.

A history of fire suppression throughout the Western US has resulted in over-stocked, closed canopy forests that exclude understory vegetation, reduce early seral habitats, reduce connectivity of open habitats, and limit edge habitats that likely provide important areas for nesting and overwintering (Panzer 2002, Roland and Matter 2007, Schultz and Crone 2008). Broadcast herbicides are often applied aerially following clearcut logging to suppress vegetation that may outcompete replanted seedlings; these applications reduce floral resources onsite and in adjacent habitat as a result of drift, and some may have some toxicity to bumble bees exposed directly or in pollen and nectar. While insecticide use is limited in Pacific Northwest forestry, applications of insecticides for forest insect pests could have non-target impacts on bumble bees using forested areas for forage or nesting habitat. The impacts of logging on bumble bees varies substantially based on location, stand characteristics (e.g., tree species and density), logging technique (e.g., ground machinery, helicopter logging, number of roads), and intensity (e.g., clearcutting vs. thinning), among other factors.

Forest management likely impacts bumble bees across the state, however data on forest management and timber sales is difficult to access. See information on the distribution of forest, along with management recommendations for forested areas in the ‘Applying Best Management Practices Across a Landscape: Management Recommendations by Land Cover Type’ section.

Fire

Anthropogenic landscape change, and specifically management strategies emphasizing fire suppression, have led to fire regimes that are significantly altered from historic patterns. Long-term fire suppression in conjunction with logging and grazing have led to fire regimes marked by large, high intensity burns (DeBano et al. 1998, Ponisio et al. 2016). The impact of fire on bumble bees and other pollinators depends on a variety of factors associated with the fire regime (e.g., interval, size, timing, intensity) and landscape (e.g., plant community, environmental variables). Fire impacts bees both directly, through immediate mortality resulting from the fire, and indirectly,

While fire can result in bumble bee mortality, burned sites often support increased bee abundance and species richness in the following years. Photo by Chris Helzer.

through reshaping the availability and distribution of resources. Overwintering queen bumble bees within a burn area likely won't survive since overwintering sites are mainly on the ground surface, however bumble bees nesting underground may survive. The survival of ground nesting bees depends primarily on nest depth (Cane and Neff 2011) while soil moisture and fire intensity also contribute to survival. Nests at a depth of 5 cm or less have a high likelihood of lethal heating during a wildfire while nests 10 cm or farther below the ground surface have a lower risk of mortality (Potts et al. 2003, Cane and Neff 2011). While little is known about the depth of bumble bee nests, a western bumble bee nest found during the summer of 2022 was located about 40cm below the ground surface (Hatfield pers. comm. 2022).

While fires, and particularly large, high intensity fires, may impact bumble bees negatively in the short term as a result of direct mortality and reduced floral availability, burned sites often support increased bee abundance (Campbell et al. 2007, Moretti et al. 2009, Grundel et al. 2010) and species richness (Moretti et al 2006, Crooks et al. 2017, Moretti et al. 2009) in years following fire due to the increase in floral resources. Abundance and richness of plant and bee communities change as time since the most recent fire increases, with a peak in richness and abundance two to three years after a burn, followed by a continual decline (Potts et al. 2003, Moretti et al. 2006). In ecosystems with an overstory, fires often result in an opening of the canopy, causing more light to reach understory plants and the ground (Moretti et al. 2004, Campbell et al. 2007). This increase in light along with the influx of water and nutrients associated with fire lead to a rapid increase in the abundance and diversity of plants (Moretti et al. 2004, Moretti et al. 2009, Cane and Neff 2011, Van Nuland et al. 2013, Olmo and Kouki 2015, Ponisio et al. 2016). A general shift from annuals offering open access and low reward to perennials with more restricted access and higher reward is also associated with fire (Potts et al. 2003). Over time, the creation of mosaic landscapes through diversity of fire regime, or pyrodiversity, results in increased pollinator species richness and plant-pollinator interactions (Wallen 2010, Ponisio et al. 2016), likely benefiting bumble bee communities.

The potential risk of wildfire is highest along the eastern slope of the central Cascades in the Grand Fir Mixed Forest and Chiwaukum Hills and Lowlands ecoregions (Figure 22). Areas with a medium wildfire risk are generally located in the same region and include the Yakima Plateau and Slopes and Wenatchee/Chelan Highlands ecoregions. Additionally, wildfire risk is high around the Blue Mountains including in the Mesic Forest Zone, Subapline-Alpine Zone, and Canyons and Dissected Highlands ecoregions.

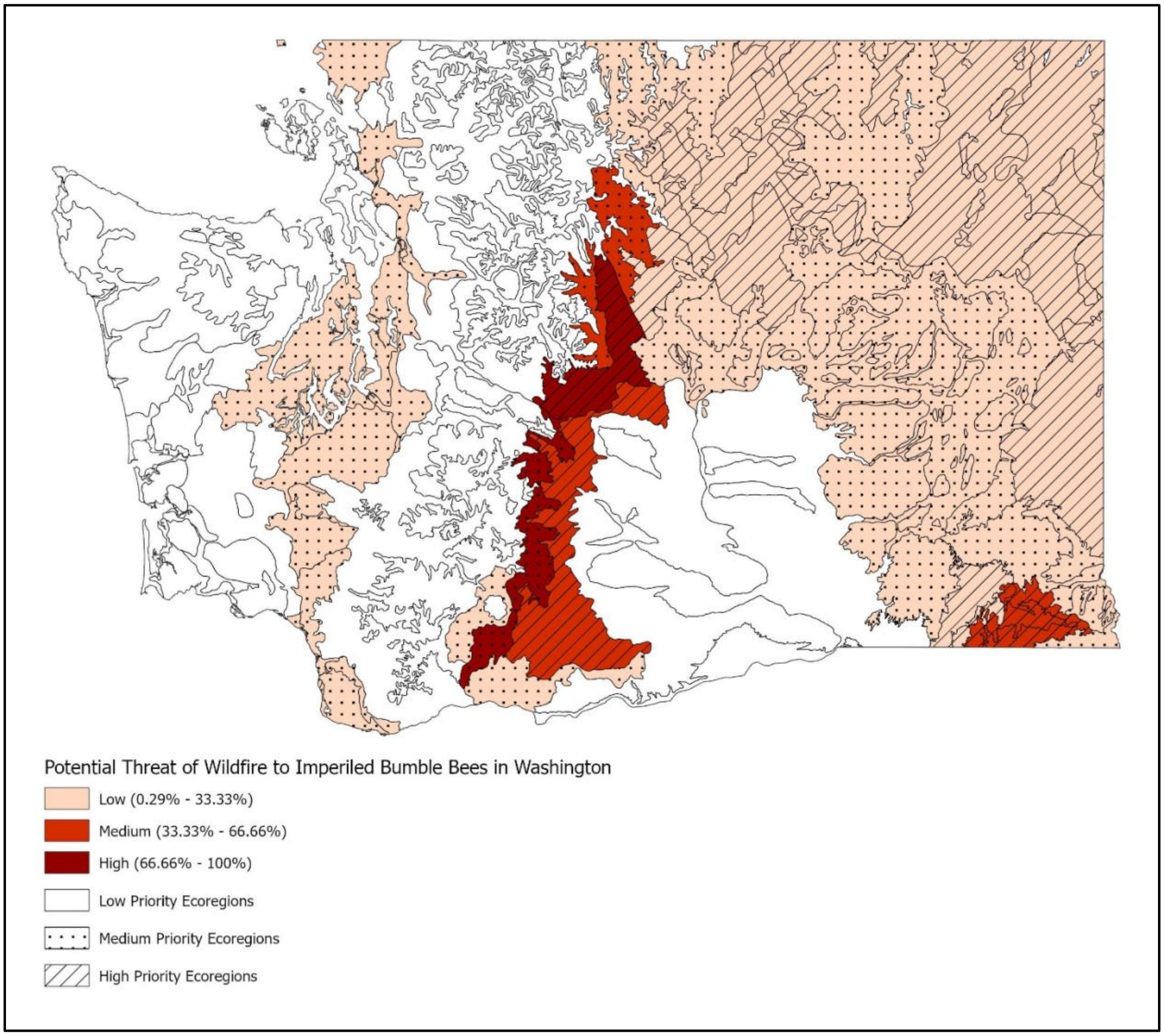


Figure 22. The potential threat of wildfire within level IV ecoregions designated as medium or high priority for conservation.

Pesticides

Many pesticides can be harmful to bumble bees, even when legal application requirements are followed. 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, and are also occasionally applied in forests and rangeland for control of insect pests. Many insecticides can cause harm to bumble bees, with impacts on survival, reproduction, behavior, and a variety of other endpoints that can affect individual and colony health as well as overall population growth. Of particular concern are the widely used, long-lived, and highly bee-toxic neonicotinoid insecticides, as well as other systemic insecticides. Systemic insecticides are water soluble, meaning that they can be taken up into the nectar and pollen of plants and actively eaten and collected by bumble bees, as well as fed to developing larvae (Hopwood et al. 2016). Some of these insecticides can persist in the environment and 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).

Insecticides sprayed to control grasshopper outbreaks on public lands across the west inflict sublethal and lethal harm to native bumble bees. Photo by the Xerces Society/Stephanie McKnight.

In addition to insecticides, fungicides and herbicides can also pose individual and combined threats to bumble bees. Fungicides are linked with subtle harm such as decreases in the number of offspring, lethargy, and decreased foraging (Bernauer et al. 2015), and have been implicated in bumble bee species decline (McArt et al. 2017, Calhoun et al. 2021). Some fungicides may reduce the capacity for bees to respond to other stressors, including other pesticides and pathogens that bees are exposed to (*reviewed in* May et al. 2019). Herbicides pose both direct and indirect threats: widespread use of herbicides removes floral resources from crop fields and neighboring areas, rangelands, forests, and other landscapes where herbicides are used. Herbicide drift can also affect the quality, diversity, and quantity of bumble bee forage, as drift-level doses of herbicides can reduce or delay flowering of non-target plants (Bohnenblust et al. 2015). Herbicides may also pose a variety of subtle harms to bumble bees when bees are exposed by contact or in nectar and pollen, including impacts to growth and development, learning and navigation, and immune response (Belsky and Joshi 2020, Thompson et al. 2022).

The risk to bumble bees from pesticide applications depends on the type of exposure (e.g., direct contact through spraying or indirect contact with or ingestion of residues after the application), the level of exposure (e.g., the dose or concentration), and the toxicity of the applied chemical to bumble bees. Bumble bees can be exposed to pesticides directly when the pesticide is applied, by contact with residues on plants and in soil, or later on by ingesting residues in nectar and pollen or contaminated food stores. Broadcast applications of pesticides toxic to bumble bees during their active periods, especially in areas with flowering plants, represent the highest-risk scenario for these insects. These types of applications can be made in agricultural areas for crop pests, in urban and other residential areas for lawn pests and mosquito control, and less commonly in forests and rangelands for insect pests. In agriculture, neonicotinoids and other systemic insecticides and fungicides are commonly applied as seed coatings on row crops. These highly mobile systemic pesticides can contaminate nearby flowering habitat through dust off, drift, and leaching. Wildflowers and soils in agricultural field margins are commonly contaminated with a complex mixture of agrochemicals at levels that could pose harm to bumble bees foraging and nesting in those areas (Botias et al. 2016, Main et al. 2020).

Pesticide risk to pollinators in medium and high priority ecoregions is highest along the eastern slope of the Cascades including in the Grand Fir Mixed Forest and Yakima Plateau and Slopes ecoregions and medium throughout a wide swath of the eastern slopes of the North Cascades, east to the Okanogan Valley, and south through the Columbia Plateau creating a horseshow around the central Columbia Plateau including in the Cascade Crest Montane Forest, Pasayten/Sawtooth Highlands, Okanogan Pine/Fir Hills, Okanogan Valley, Channeled Scablands, Loess Islands, and Palouse Hills ecoregions (Figure 23). This estimation of pesticide risk only includes estimates from agricultural pesticide applications and not from other varied uses including residential applications, vector control (mosquito management) applications, or applications to rangelands or forested areas.

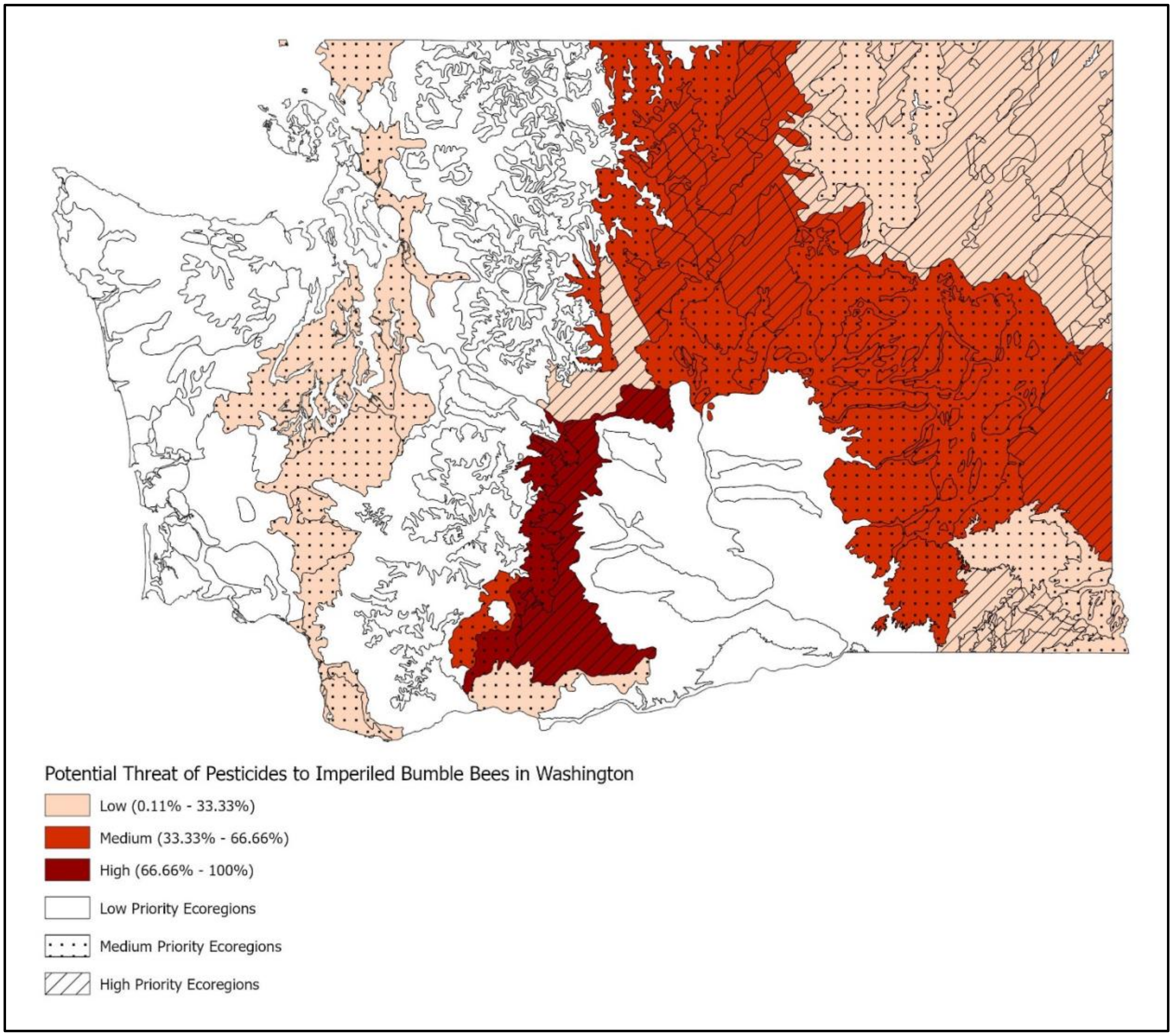


Figure 23. The potential threat of pesticides within level IV ecoregions designated as medium or high priority for conservation.

Climate Change

Recent evidence suggests that climate change is causing changes in bumble bee distribution in terms of latitude and elevation across a range of landscapes on multiple continents (Kerr et al. 2015). A regional analysis of climate change impacts in the Pacific Northwest indicates that climate change will reduce habitat suitability, particularly at high altitudes (Koch et al. 2019). Climate change can result in changes in bumble bee life history, community interactions and resources, and habitat structures that bumble bees rely on (Cameron et al. 2011, Hatfield et al. 2014, Koch et al. 2019). In response to changing climatic conditions, alpine tree lines can advance upslope, potentially altering previously open habitats and degrading areas previously used by bumble bees for foraging, nesting, and overwintering (Kerr et al. 2015). While climate change is most likely to have the largest impact on species occupying high elevation sites including the frigid, golden-belted, and western bumble bees, the impacts of climate change will likely lead to range shifts and physiological impacts to many bumble bee species (Williams et al. 2014, Miller-Struttmann et al. 2015, Koch et al. 2019).

Climate change risk measures the difference between historic and projected future climate conditions for minimum temperature, maximum temperature, and precipitation. Changes in temperature and precipitation can negatively impact bumble bees through changing bumble bee life history, community interactions and resources, and habitat structures that bumble bees rely on (Cameron et al. 2011, Hatfield et al. 2014, Koch et al. 2019). Understanding the geographic distribution and relative potential impact of climate change can help to explain changes in species' distributions and inform management that promotes climate resilient ecosystems. Climate change risk is either medium or high for all ecoregions in Washington (Figure 24). High risk ecoregions include those along the eastern slope of the Cascades including the Cascade Crest Montane Forest, Grand Fir Mixed Forest, Yakima Plateau and Slopes, Chiwaukum Hills and Lowlands, Wenatchee/Chelan Highlands, and Okanogan Pine/Fir Hills ecoregions as well as the Okanogan Highland Dry Forest, Okanogan-Colville Xeric Valleys and Foothills, Western Selkirk Maritime Forest, and Selkirk Mountains ecoregions in the northeastern region of the state.

Additionally, the species distribution models for the eight bumble bee species highlighted in this document show a general habitat and range shift northward. For some species this shift is already noticeable in the difference between historic and recent observations. This shift validates the general forecast that climate change will force many species to shift either north or to higher elevations to maintain suitable environmental conditions and track range shifts in the flora on which they rely.

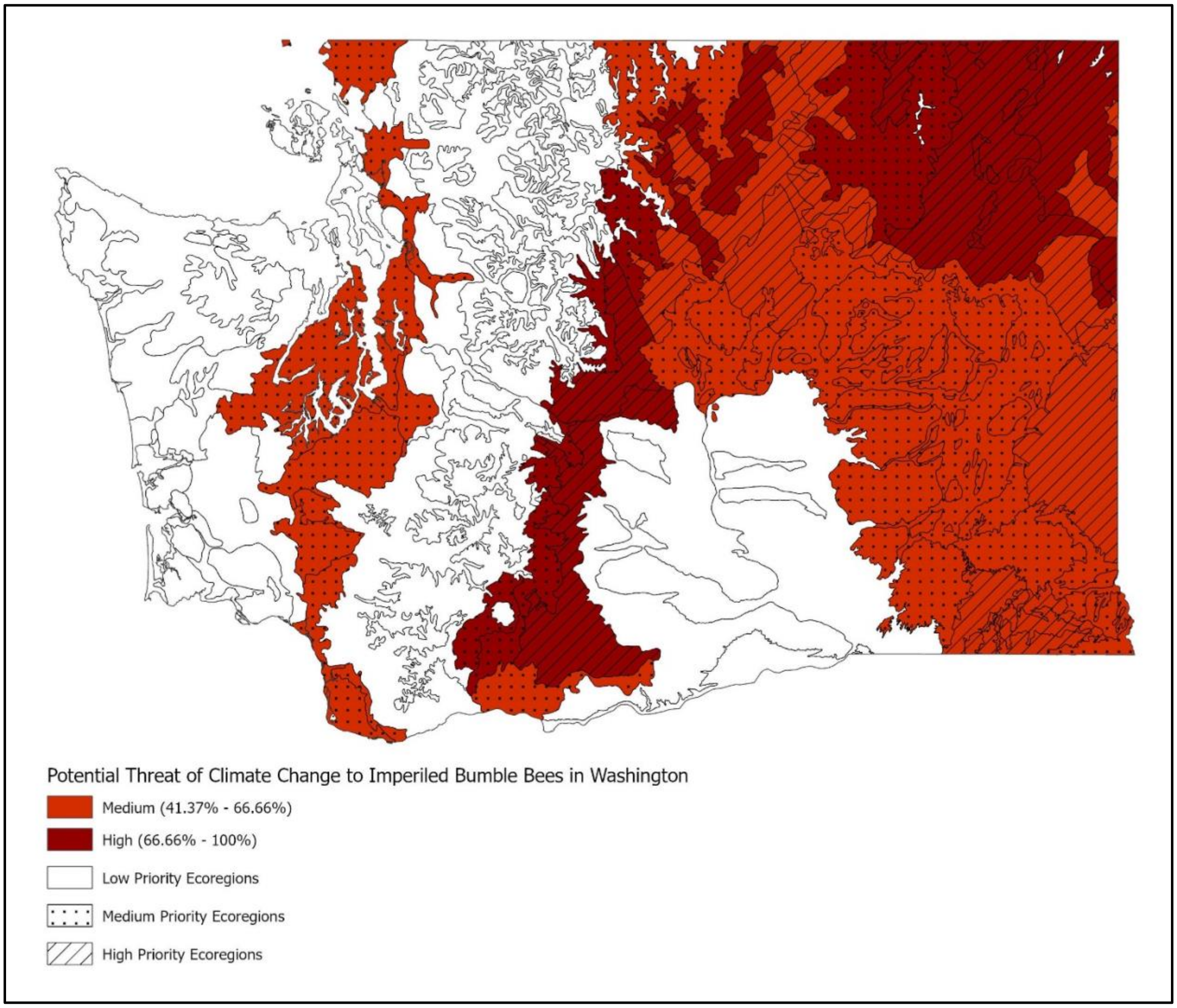


Figure 24. The potential threat of climate change within level IV ecoregions designated as medium or high priority for conservation.

Genetic Factors

Since many bumble bee species have recently undergone a dramatic decline in range and relative abundance, reduced genetic diversity and other genetic factors may lead to increased pathogen susceptibility (Zayed 2009), making these species especially vulnerable to extinction (Altizer et al. 2003, Whitehorn et al. 2009). Recent research indicates that populations of declining bumble bees, in particular the western and American bumble bees, have lower genetic diversity compared to populations of co-occurring stable species (Cameron et al. 2011, Lozier et al. 2011).

Given that the threat of reduced genetic diversity results from population declines rather than directly from external factors, we were unable to quantify the relative geographic impact of this threat in a similar way to other potential threats.

RESEARCH, INVENTORY, AND MONITORING OPPORTUNITIES

While research into bumble bee distribution, habitat associations, and nesting and overwintering habits have increased in recent years, many gaps still remain in our understanding of these species. Gathering data on occurrences, including foraging, nesting, and overwintering individuals, and habitat associated with those occurrences, is essential to expanding our understanding of these species, potential threats driving population trends and species distribution, and management strategies to protect existing populations and expand suitable habitat. In particular, very little is known about bumble bee nesting and overwintering ecology. Increasing efforts to identify bumble bee nests and overwintering sites should be prioritized. Research, inventory, and monitoring should be a key priority in the coming years.

Completing bumble bee surveys and submitting data to the Pacific Northwest Bumble Bee Atlas is a way that anyone, including agency staff, private landowners, and community members, can contribute to bumble bee conservation. Visit https://www.pnwbumblebeeatlas.org/ to learn more about the project and how to become involved. While completing bumble bee surveys anywhere within the state of Washington will provide valuable information, surveys in historically under surveyed regions of the state are particularly valuable. Increasing the data on bumble bees and associated habitat in level IV ecoregions identified as medium or high priority in this conservation strategy, or within the current predicted potential geographic distribution of focal species, will improve the accuracy of modeled species distribution and allow for more targeted conservation.

GLOSSARY

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, where pollen is released through an aperture at the terminus of each anther rather than being easily accessible). Many genera within the *Ericaceae* (heath or heather) family, including *Arctostaphylos* (e.g., manzanita) and *Vaccinium* (e.g., blueberries and cranberries) have poricidal anthers and rely on buzz pollination. Additionally, many plants in the *Solinaceae* (nightshade) family including tomatoes and eggplants are most effectively pollinated through buzz pollination.

Complete metamorphosis - Development involving egg, larval, pupal, and adult phases during which morphology is distinct.

Corbicula - The area on a bees' hind leg where pollen is stored for transport. This area is located on the outer surface of the tibia of female bumble bees. Bumble bees in the *Psithyrus* subgenus, or cuckoo bumble bees, do not have corbicula as they rely on other species to raise there young and therefore do not actively collect pollen.

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.

Cuckoo bumble bee - Bumble bee species that depend on other bumble bees to serve as a host. Because they have no corbicula, or pollen basket located on their hind leg, they have an obligate dependency on social bumble bees to collect pollen on which to rear their young. All members of the species have equal status, and are reproductive, and there is no division of labor within the species.

Eusocial - Living in colonies of related individuals that cooperate to support the colony.

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.

Floral morphology - The structure of a flower. This includes characteristics of the corolla, carpel (female reproductive structures), and stamen (male reproductive structures).

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

Generalist foragers - 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.

Gyne - A newly produced queen that will continue the life cycle the following year.

Hibernacula - The location where a queen bumble bee overwinters.

Mosaic landscape - A landscape with a range of characteristics in distinct groupings. This may include plant community, animal community, fire history, environmental variables, and management techniques.

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

Neonicotinoid - A class of insecticides used widely on farms and in urban landscapes. These insecticides are systemic chemicals, absorbed into the plant and present in pollen and nectar, making them toxic to pollinators that feed on them.

Optimal foraging theory - A theory that suggests that bumble bees preferentially forage close to their nests in order to reduce the energetic expenditure of longer flights.

Pesticide - A chemical compound used to control a pest. This includes insecticide (which control insects), herbicide (which control plants), and fungicides (which control fungi).

Pyrodiversity - The creation of mosaic landscapes through diversity of fire regime.

Senesce - Deteriorate with age.

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APPENDICES

Appendix A: Species Profiles

The eight focal species of this conservation strategy have differing distributions on a state (Figure A 1, Table B 1) and continental scale. Understanding the distribution of each species through occurrence records and modeled species distribution informs where conservation efforts should be focused, and locations within the state of Washington where management will most benefit specific species. The following species profiles provide information on the general range, predicted potential geographic distribution within the state, and predicted potential geographic distribution by land manager for all eight species. In order to protect the exact location of sensitive species, occurrence records may be slightly offset from the actual locations. Given that the predicted potential geographic distribution for each species is based on a complex modeling process, differences in predicted potential geographic distribution between time periods may not always align with the number of occurrence records or trend in relative abundance.

Comparing occurrence records between time periods is challenging given substantial differences in sampling effort and unequal time periods. We therefore use relative abundance, a measure of the abundance of a single species in a certain time period compared to the abundance of all bumble bee species during that time period, to better understand species trends. While relative abundance is often a better metric than actual abundance for understanding trends, relative abundance may be biased as a result of differences in sampling effort resulting from geography (e.g., concentrated sampling near population centers) and targeted surveys (e.g., surveys focused on a single species rather than all bumble bee species), among other factors. Given the limitations associated with relative abundance and actual abundance, we present both metrics and encourage users to exercise caution when interpreting this information.

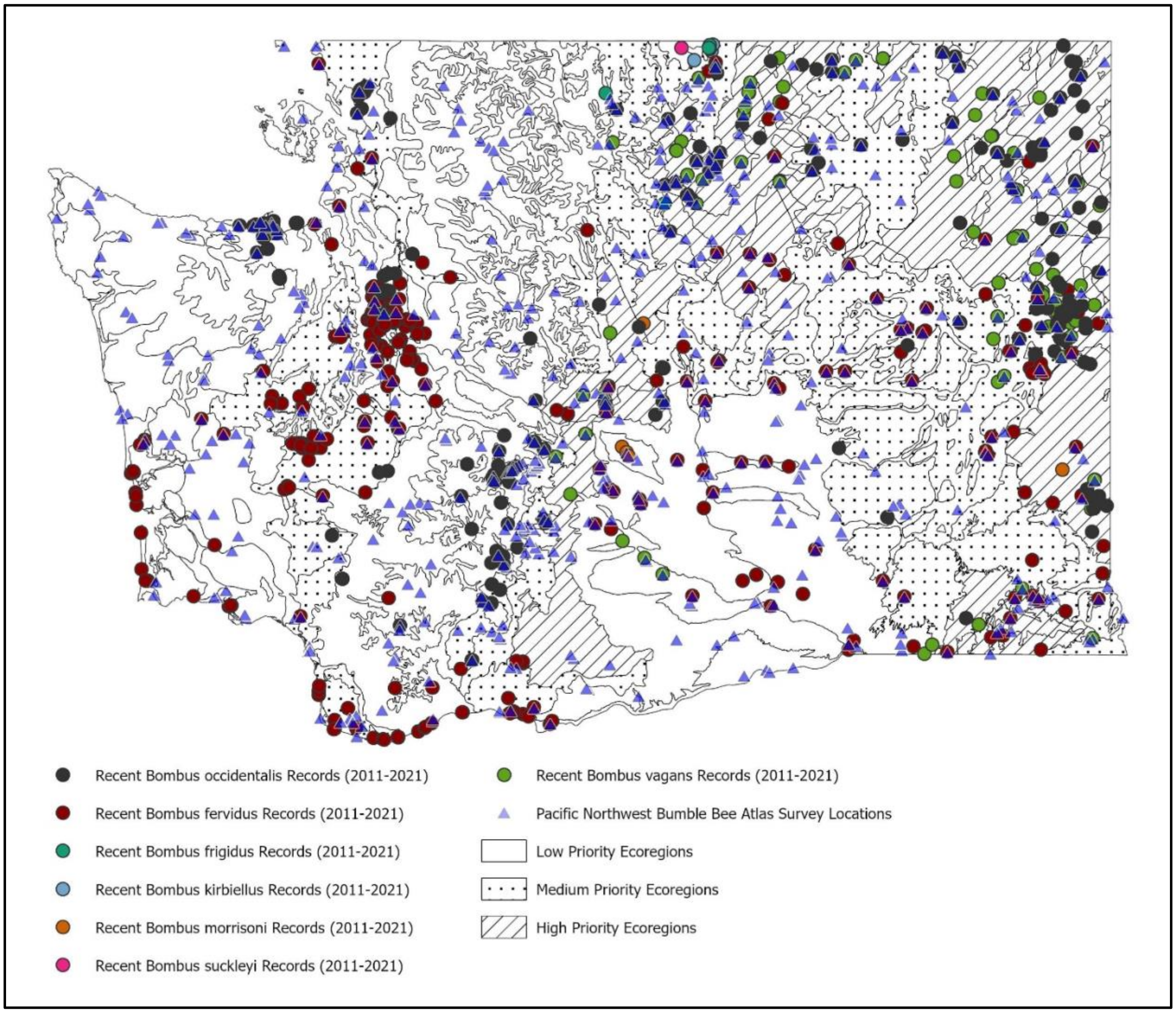
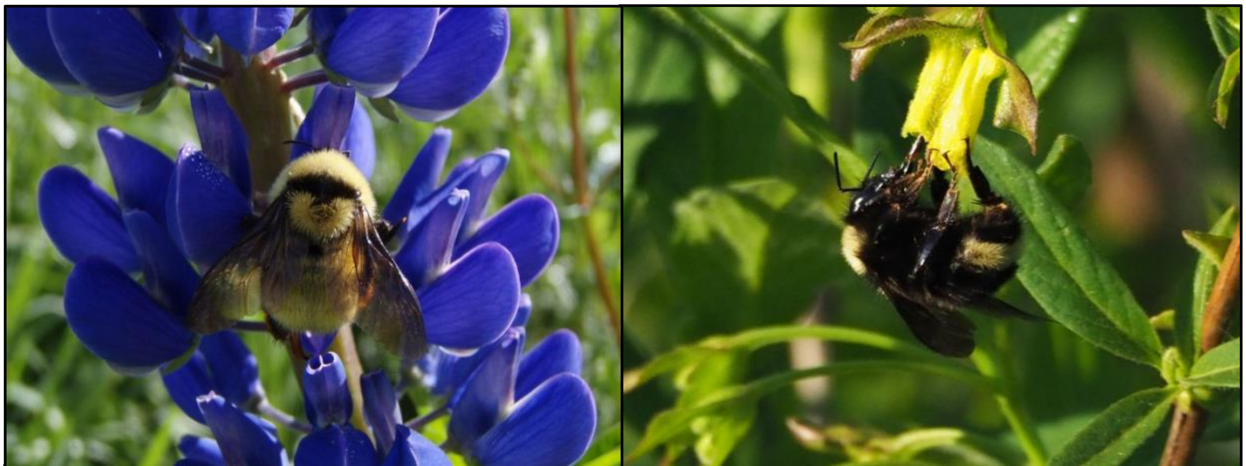


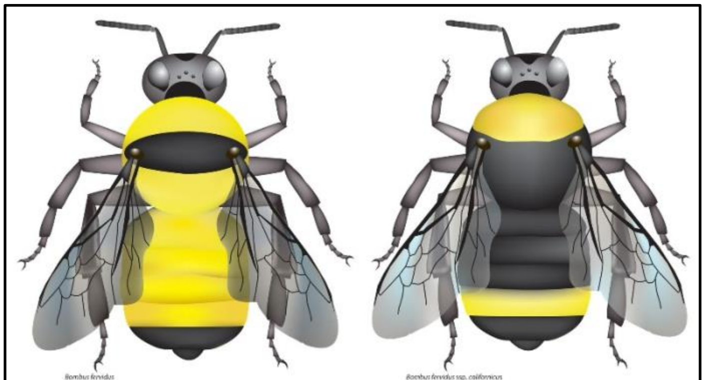
Figure A 1. Recent (2011-2021) records of all focal species in the state of Washington and locations where surveys were conducted for the Pacific Northwest Bumble Bee Atlas between 2018 and 2021.

Yellow Bumble Bee (*B. fervidus*)



Two common color variants of the yellow bumble bee. Photos by Leif Richardson (left) and Scott Ramos (right).

Distribution



Illustrations of the yellow bumble bee. Illustrations by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

The yellow bumble bee ranges widely across the continental US and adjacent southern Canada (Figure A 2). In Washington state, this species occurs primarily in the Puget Lowlands and throughout the Columbia Plateau ecoregions as well as throughout the eastern region of the state (Figure A 3, Table B 2). This species has a strong shift in black/yellow color patterns from mostly yellow in the east, to largely black along the Pacific Coast (where it was formerly recognized as a separate species, *B. californicus*); in the Pacific Northwest, both extreme color patterns and their intermediates are found.

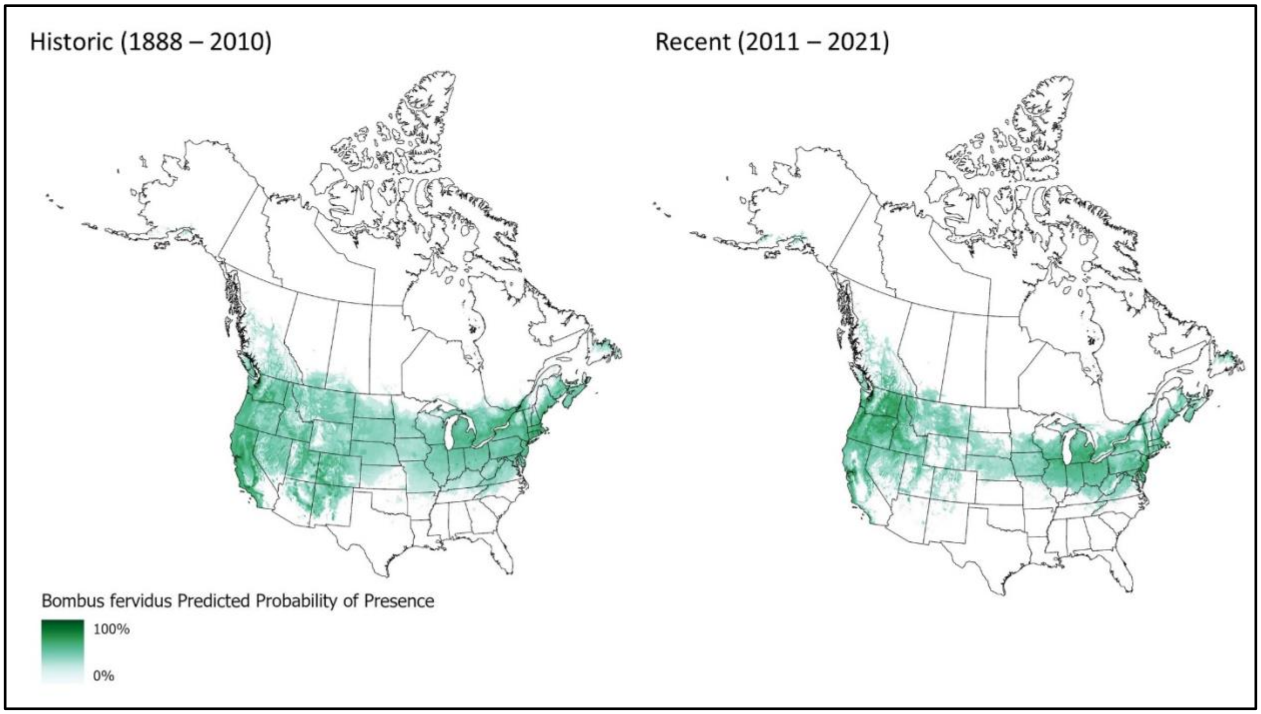


Figure A 2. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the yellow bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

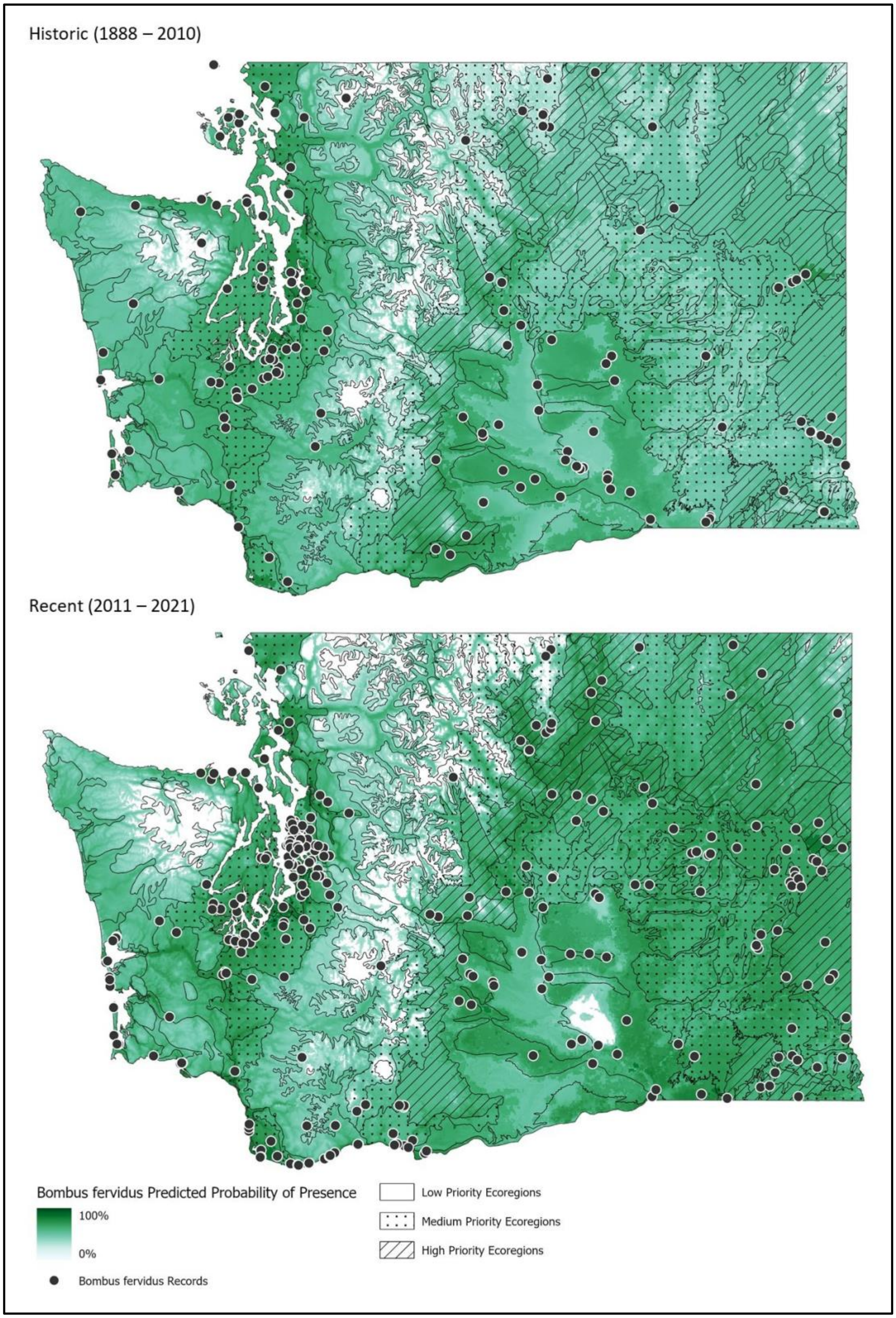


Figure A 3. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the yellow bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations

From the data available to us, historically (pre-2011), there are 313 records of this species in Washington, while recently (2011-2021) there are 268 records. Both historic and recent occurrence records are clustered in the Puget Lowlands and broadly distributed throughout the Columbia Plateau (Figure A 3). Taking into account survey effort, the Pacific Northwest Bumble Bee Atlas detected this species less often than would be expected from historic data. Atlas surveyors made observations primarily in the lower elevation of the Puget Lowlands, and Snake River Plain ecoregions; lesser numbers were observed in the Columbia Plateau, Blue Mountains, and Idaho Batholith ecoregions. The species is assessed as Vulnerable by the IUCN (Hatfield et al. 2015).

Relative Abundance

Historic (pre-2011) relative abundance of this species in Washington state was 9.78% while recent (2011-2021) relative abundance is 5.64%. This represents a 43.33% decline in relative abundance. See Table A 1 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the yellow bumble bee by land owner and land manager and Table B 2 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager

During the recent time period (2011-2021) the vast majority of occurrence records of this species were made on lands in the "other" category (178 records), encompassing primarily privately owned lands as well as Tribal Nations, followed by lands managed by the US Forest Service (18 records) and city or municipality property (18 records), lands managed by WDFW (14 records), and lands managed by DNR (10 records) (Table A 1).

Based on the SDM in Washington state the majority of the species' suitable habitat (65.20%) overlaps with primarily privately owned lands followed by USFS (6.59%) and city and municipality (6.59%) (Table A 1).

Table A 1. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the yellow bumble bee by land owner and land manager in Washington.

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. fervidus* Recent Occurrence Records	*B. fervidus* Recent Relative Abundance	Percent *B. fervidus* Predicted Potential Geographic Distribution Overlap
Federal Government	US Forest Service	733	79	10.78%	18	2.46%	6.59%
Federal Government	US Bureau of Land Management	61	9	14.75%	7	11.48%	2.56%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	4	6.06%	1.47%
Federal Government	National Park Service	130	7	5.38%	2	1.54%	0.73%
Federal Government	US Bureau of Reclamation	11	2	18.18%	1	9.09%	0.37%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	4	20.00%	1.47%
Federal Government	Army Corps of Engineers	8	2	25.00%	2	25.00%	0.73%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	14	8.48%	5.13%
State Government	WA Dept of Natural Resources	221	20	9.05%	10	4.52%	3.66%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	5	3.36%	1.83%
State Government	State University	67	14	20.90%	7	10.45%	2.56%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. fervidus* Recent Occurrence Records	*B. fervidus* Recent Relative Abundance	Percent *B. fervidus* Predicted Potential Geographic Distribution Overlap
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	18	10.98%	6.59%
City, Municipal, or County Government	County	64	8	12.50%	3	4.69%	1.10%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	178	5.98%	65.20%

Frigid Bumble Bee (*B. frigidus*)

Left: Photo of the frigid bumble bee. Photo by Daniel Brisbin. Right: Illustration of the frigid bumble bee. Illustration by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

Distribution

The frigid bumble bee is found from Alaska to the eastern maritime provinces of Canada, with populations sparingly distributed at high elevation sites southward into the Pacific Northwest, along the Rocky Mountains, and into a few Midwestern and New England states (Figure A 4). As this species is naturally rare in Washington, it is difficult to draw general conclusions about the species' distribution in the state (Figure A 5, Table B 3).

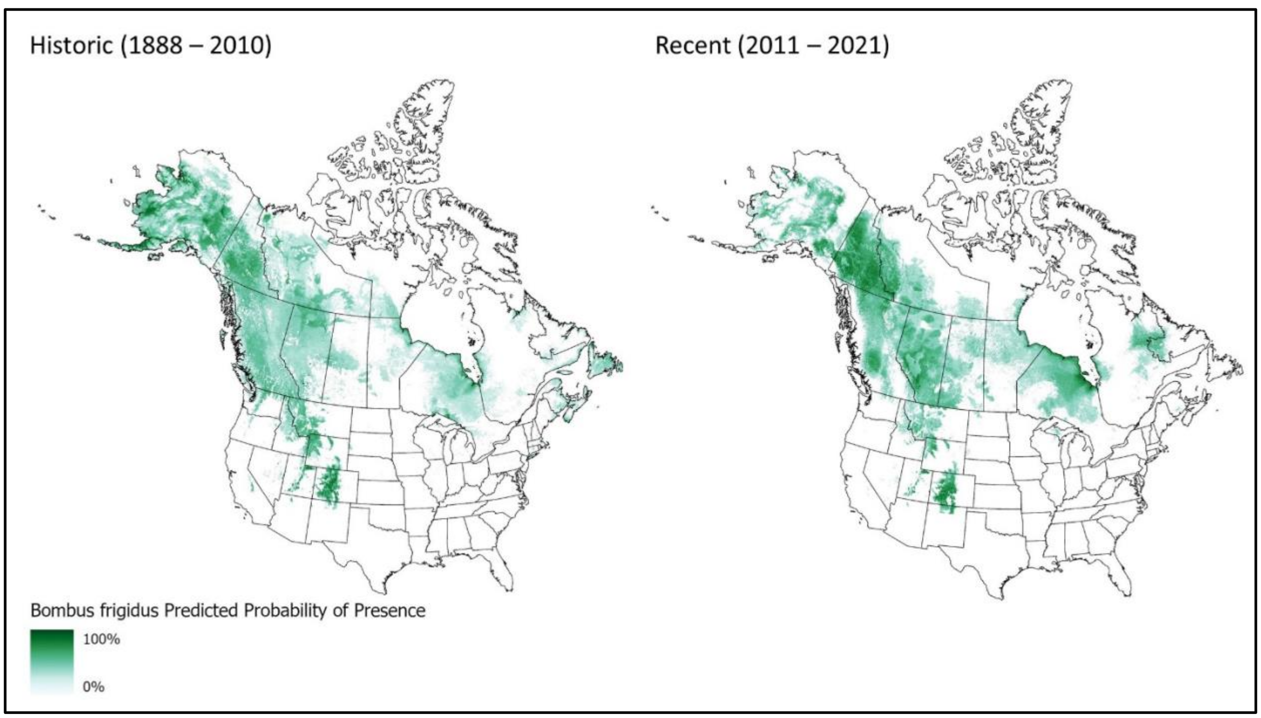


Figure A 4. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the frigid bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

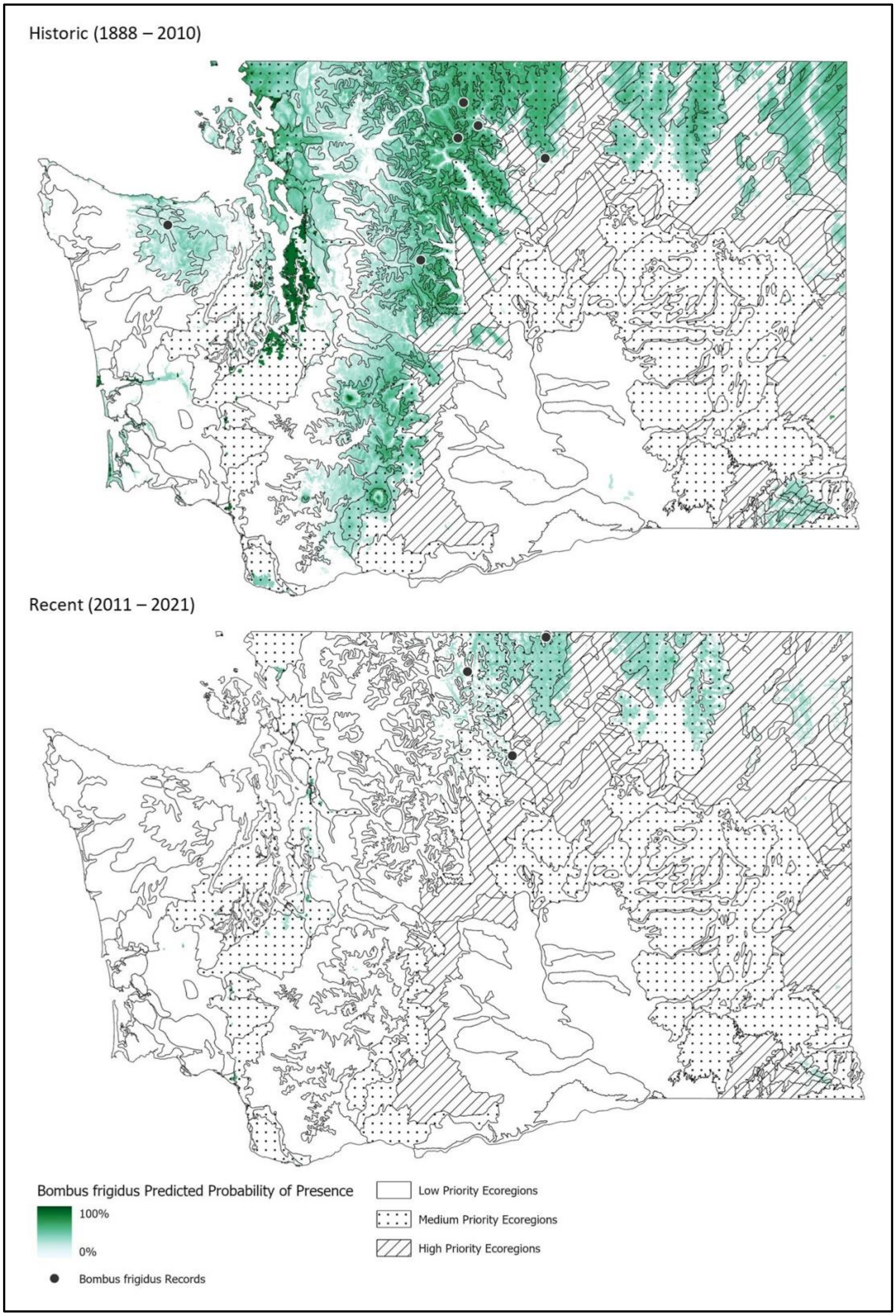


Figure A 5. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the frigid bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations
This species has only been observed a handful of times in the state of Washington. From the data available to us, during both the historic (pre-2011) and recent (2011-2021) time periods there are only two records of the species in the state of Washington, though in vastly different parts of the state. Historic records are both on the Olympic Peninsula, while recent records are along the Canadian border in the north central region of the state (Figure A 5). The historic record from the west coast of the Olympic Peninsula is most likely the Fuzzy-horned bumble bee (*B. mixtus*), and not the frigid bumble bee (Hatfield Pers. Comm. 2022).

Relative Abundance
Historic (pre-2011) relative abundance of this species in Washington state was 0.06% while recent (2011-2021) relative abundance is 0.04%. This represents a 33.33% decline in relative abundance, however given the small number of occurrence records it is difficult to draw conclusions about the species' trend. See Table A 2 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the frigid bumble bee by land owner and land manager and Table B 3 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager
During the recent time period (2011-2021) one occurrence record was made on lands managed by the USFS and one was made on lands in the "other" category (Table A 2).

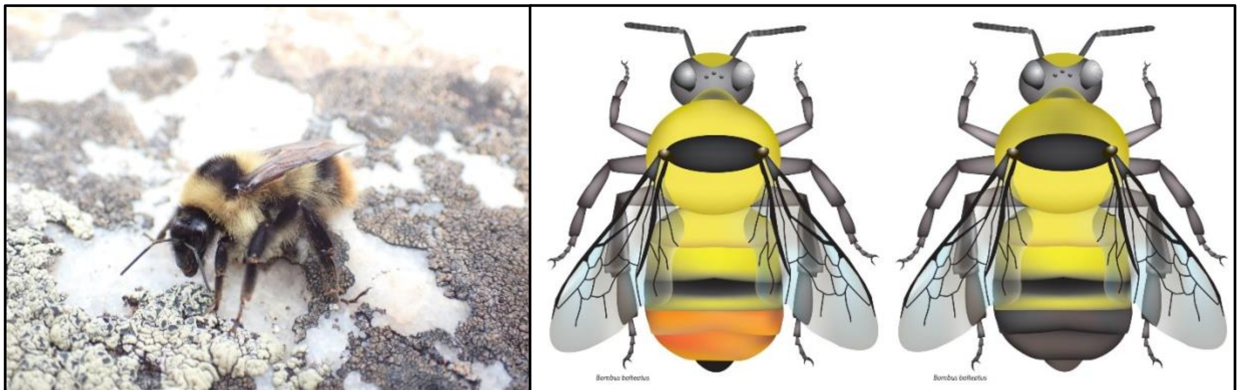
Based on the SDM in Washington state, 50% of the species' predicted potential geographic distribution overlaps with lands managed by "Other" and 50% overlaps with lands managed by the USFS (Table A 2).

Table A 2. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the frigid bumble bee by land owner and land manager in Washington.

Owner	**Manager**	**All Recent Occurrence Records**	**All Recent Occurrence Records of Focal Species**	**Relative Abundance of Focal Species**	***B. frigidus* Recent Occurrence Records**	***B. frigidus* Recent Relative Abundance**	**Percent *B. frigidus* Predicted Potential Geographic Distribution Overlap**
Federal Government	US Forest Service	733	79	10.78%	1	0.14%	50.00%
Federal Government	US Bureau of Land Management	61	9	14.75%	0	0.00%	0.00%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	0	0.00%	0.00%
Federal Government	National Park Service	130	7	5.38%	0	0.00%	0.00%
Federal Government	US Bureau of Reclamation	11	2	18.18%	0	0.00%	0.00%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.00%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.00%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	0	0.00%	0.00%
State Government	WA Dept of Natural Resources	221	20	9.05%	0	0.00%	0.00%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	0	0.00%	0.00%
State Government	State University	67	14	20.90%	0	0.00%	0.00%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. frigidus* Recent Occurrence Records	*B. frigidus* Recent Relative Abundance	Percent *B. frigidus* Predicted Potential Geographic Distribution Overlap
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	0	0.00%	0.00%
City, Municipal, or County Government	County	64	8	12.50%	0	0.00%	0.00%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	1	0.03%	50.00%

Golden-belted Bumble Bee (*B. kirbiellus*)



Left: Photo of the golden-belted bumble bee. Photo by Katie Lamke. Right: Illustrations of the golden-belted bumble bee. Illustrations by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

Distribution

The golden-belted bumble bee, also referred to as the high country bumble bee, occurs only in arctic and alpine areas of North America, with its range extending south from Alaska and arctic Canada into the Rocky Mountains to New Mexico along the spine of mountain ranges (Figure A 6). Isolated populations also occur in the Sierra Nevada Mountains of California and sparingly at high elevation in the Pacific Northwest. Always uncommon in the region, the bee was located at several sites in the Northern Cascade ecoregion (Figure A 7, Table B 4). The species is assessed as Data Deficient by the IUCN (Hatfield et al. 2016).

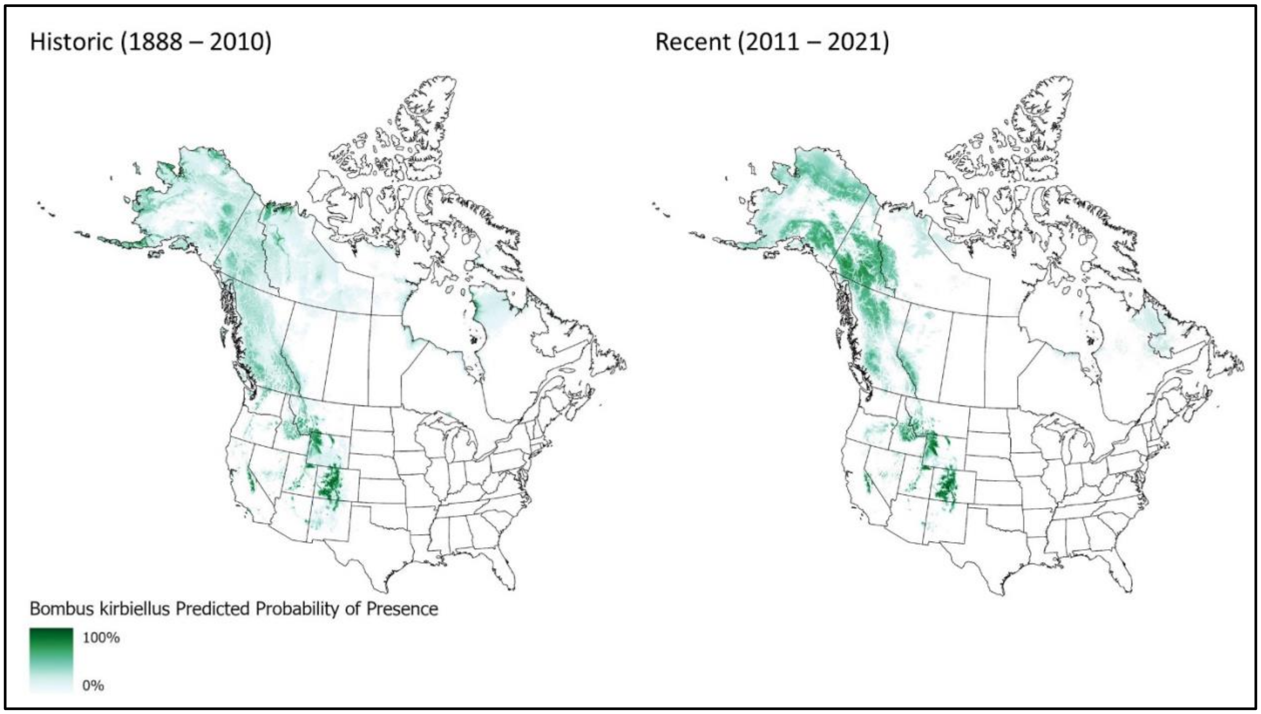


Figure A 6. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the golden-belted bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

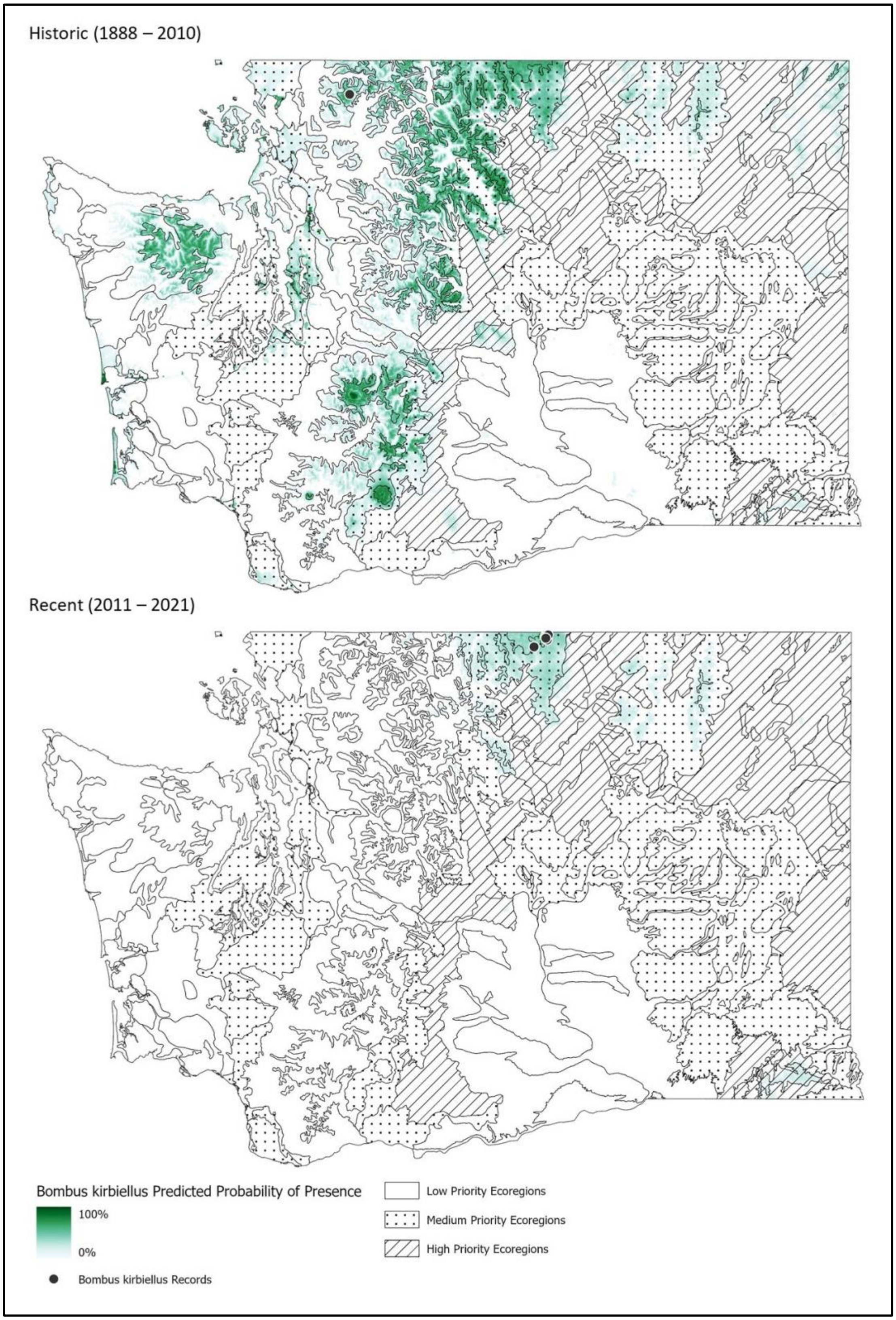


Figure A 7. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the golden-belted bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations

From the data available to us, historically (pre-2011), there is only a single record of this species in Washington, while recently (2011-2021) there are four records. This aligns with our understanding that Washington is on the edge of this species' range. Both historic and recent occurrences are located in the North Cascades ecoregion (Figure A 7).

Relative Abundance

Historic (pre-2011) relative abundance of this species in Washington state was 0.03% while recent (2011-2021) relative abundance is 0.08%. This represents a 166.67% increase in relative abundance, however given the small number of occurrence records it is difficult to draw conclusions about the species' trend. See Table A 3 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the golden-belted bumble bee by land owner and land manager and Table B 4 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager

During the recent time period (2011-2021) all occurrence records of this species were made on lands managed by the USFS (Table A 3).

Based on the SDM in Washington state, 100% of the species' predicted potential geographic distribution overlaps with lands managed by the USFS (Table A 3).

Table A 3. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the golden-belted bumble bee by land owner and land manager in Washington.

Owner	**Manager**	**All Recent Occurrence Records**	**All Recent Occurrence Records of Focal Species**	**Relative Abundance of Focal Species**	***B. kirbiellus* Recent Occurrence Records**	***B. kirbiellus* Recent Relative Abundance**	**Percent *B. kirbiellus* Predicted Potential Geographic Distribution Overlap**
Federal Government	US Forest Service	733	79	10.78%	4	0.55%	100.00%
Federal Government	US Bureau of Land Management	61	9	14.75%	0	0.00%	0.00%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	0	0.00%	0.00%
Federal Government	National Park Service	130	7	5.38%	0	0.00%	0.00%
Federal Government	US Bureau of Reclamation	11	2	18.18%	0	0.00%	0.00%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.00%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.00%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	0	0.00%	0.00%
State Government	WA Dept of Natural Resources	221	20	9.05%	0	0.00%	0.00%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	0	0.00%	0.00%
State Government	State University	67	14	20.90%	0	0.00%	0.00%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. kirbiellus* Recent Occurrence Records	*B. kirbiellus* Recent Relative Abundance	Percent *B. kirbiellus* Predicted Potential Geographic Distribution Overlap
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	0	0.00%	0.00%
City, Municipal, or County Government	County	64	8	12.50%	0	0.00%	0.00%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	0	0.00%	0.00%

Morrison Bumble Bee (*B. morrisoni*)

Left: Photo of the Morrison bumble bee. Photo by Steve Sheehy. Center: Photo of Morrison bumble bee. Photo by the Xerces Society/Leif Richardson. Right: Illustration of the Morrison bumble bee. Illustration by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

Distribution

The range of Morrison bumble bee occurs almost entirely within the Intermountain West extending into British Columbia (Figure A 8). While still found broadly throughout this range, the species is assessed as Vulnerable by the IUCN (Hatfield et al. 2014). The majority of recent observations of this species are from the east slope of the Cascades and the Columbia Plateau (Figure A 9, Table B 5).

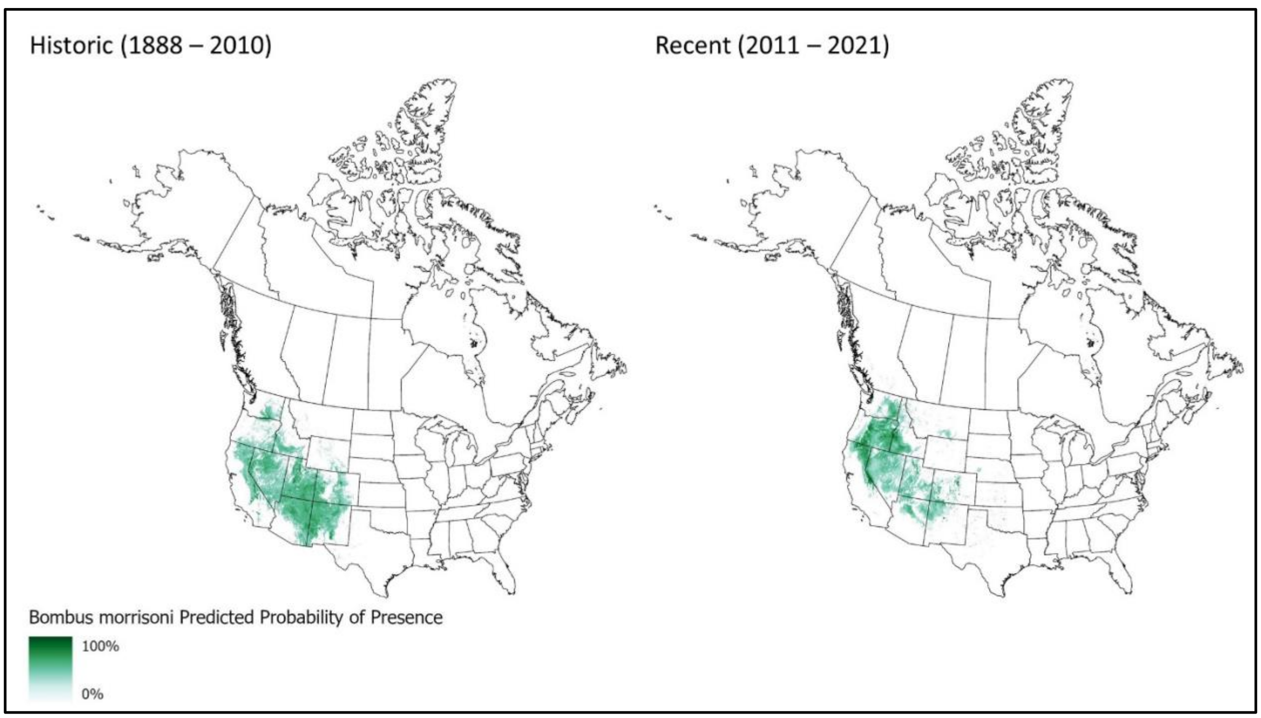


Figure A 8. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the Morrison bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

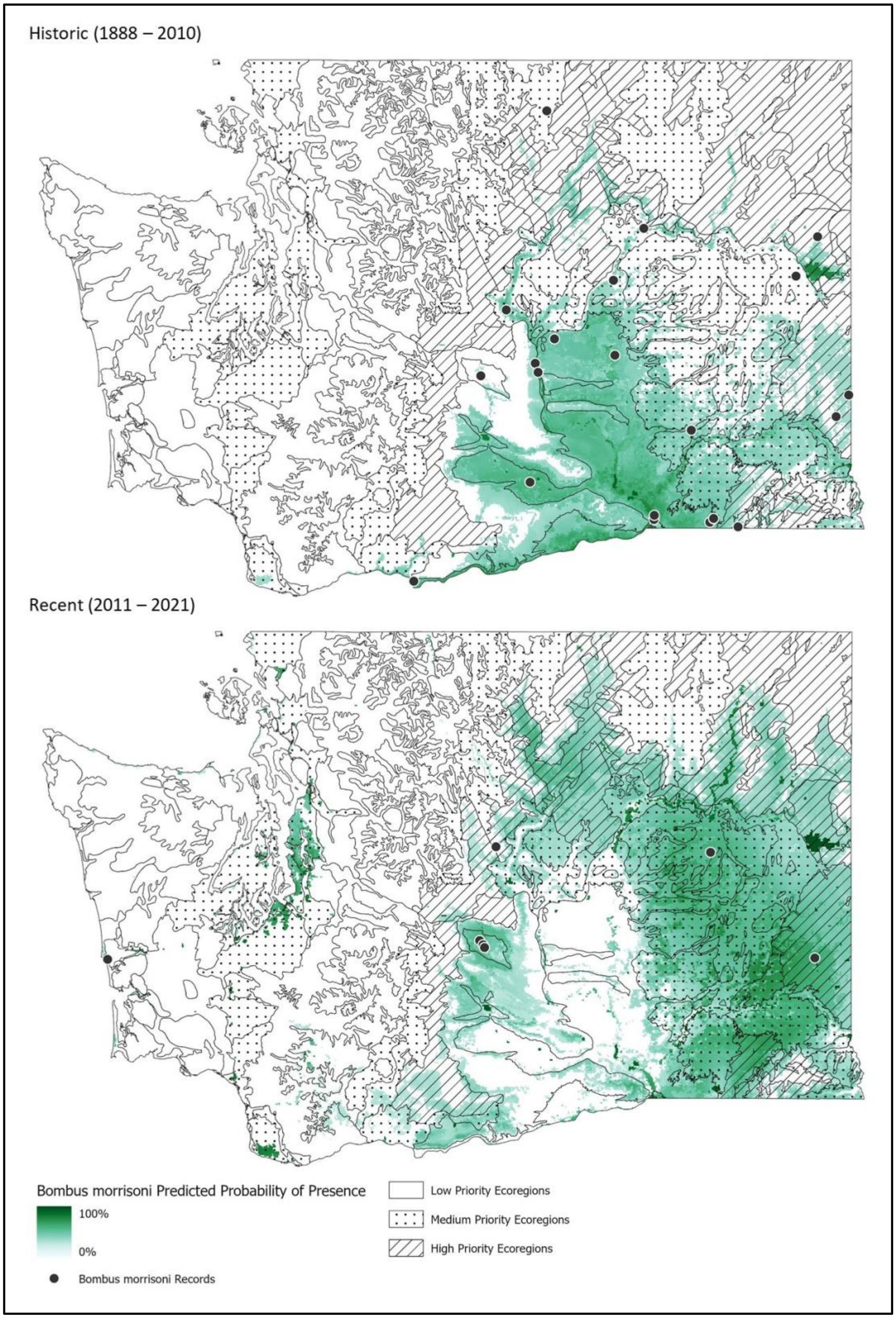


Figure A 9. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the Morrison bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations

From the data available to us, historically (pre-2011), there are 32 records of this species in Washington, while recently (2011-2021) there are only six records. Both historic and recent records are distributed throughout the Columbia Plateau (Figure A 9).

Relative Abundance

Historic (pre-2011) relative abundance of this species in Washington state was 1.00% while recent (2011-2021) relative abundance is 0.13%. This represents a 87.00% decline in relative abundance. See Table A 4 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the Morrison bumble bee by land owner and land manager and Table B 5 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager

During the recent time period (2011-2021), four occurrence records of this species were made on lands in the “other” category, one from lands managed by WDFW, and one from lands managed by the USFS (Table A 4).

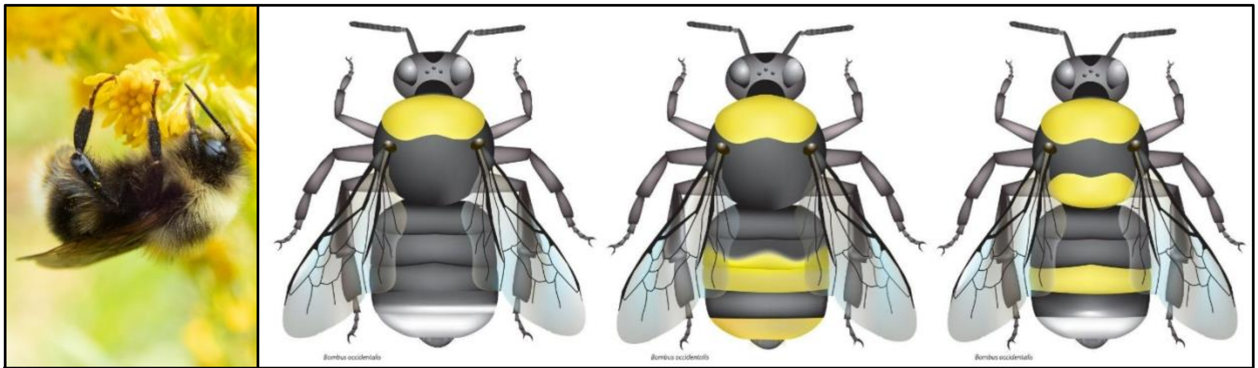
Based on the SDM in Washington state, the majority of the species’ predicted potential geographic distribution (66.67%) overlaps with lands managed by “other”, 16.67% overlaps with lands managed by the USFS, and 16.67% overlaps with lands managed by WDFW (Table A 4).

Table A 4. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the Morrison bumble bee by land owner and land manager in Washington.

Owner	**Manager**	**All Recent Occurrence Records**	**All Recent Occurrence Records of Focal Species**	**Relative Abundance of Focal Species**	***B. morrisoni* Recent Occurrence Records**	***B. morrisoni* Recent Relative Abundance**	**Percent *B. morrisoni* Predicted Potential Geographic Distribution Overlap**
Federal Government	US Forest Service	733	79	10.78%	1	0.14%	16.67%
Federal Government	US Bureau of Land Management	61	9	14.75%	0	0.00%	0.00%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	0	0.00%	0.00%
Federal Government	National Park Service	130	7	5.38%	0	0.00%	0.00%
Federal Government	US Bureau of Reclamation	11	2	18.18%	0	0.00%	0.00%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.00%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.00%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	1	0.61%	16.67%
State Government	WA Dept of Natural Resources	221	20	9.05%	0	0.00%	0.00%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	0	0.00%	0.00%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. morrisoni* Recent Occurrence Records	*B. morrisoni* Recent Relative Abundance	Percent *B. morrisoni* Predicted Potential Geographic Distribution Overlap
State Government	State University	67	14	20.90%	0	0.00%	0.00%
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	0	0.00%	0.00%
City, Municipal, or County Government	County	64	8	12.50%	0	0.00%	0.00%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	4	0.13%	66.67%

Western Bumble Bee (*B. occidentalis*)



Left: Photo of the western bumble bee. Photo by Rich Hatfield. Right: Illustrations of the western bumble bee. Illustrations by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

The western bumble bee, initially considered a single species, has recently been divided into two species, *B. occidentalis* sensu stricto and *B. mckayi* (Franklin 1913, Thorp and Shepherd 2005, Cameron et al. 2007, Bertsch et al. 2010, Williams et al. 2012, Owen and Whidden 2013, Sheffield et al. 2016, Williams 2021). The species now known as *B. occidentalis* sensu stricto, referred to as *B. occidentalis* or the western bumble bee in this publication, is generally distributed south of 55° N while the species now known as *B. mckayi* is distributed north of 55° N. Therefore, all individuals in Washington state, and in the Western US with the exception of Alaska, are considered *B. occidentalis* sensu stricto.

Distribution

The western bumble bee (*B. occidentalis* sensu stricto) 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 (Figure A 10). In Washington, the western bumble bee was once found throughout much of the state, with the potential exception of portions of the Columbia Plateau. The present-day predicted potential geographic distribution of the western bumble bee in Washington and Oregon is significantly smaller than the historic predicted potential geographic distribution (Figure A 10, Figure A 11), largely restricted to high elevation sites, mostly east of the Cascade Crest, but also on the Olympic Peninsula. The species is assessed as Vulnerable by the IUCN (Hatfield et al. 2015), and as a species of concern in other status assessments (Natureserve 2022, Cameron et al. 2011). A petition was submitted to the USFWS for the western bumble bee to be protected under the Endangered Species Act in September 2015, which resulted in a positive 90 day finding in March 2016 (USFWS 2022).

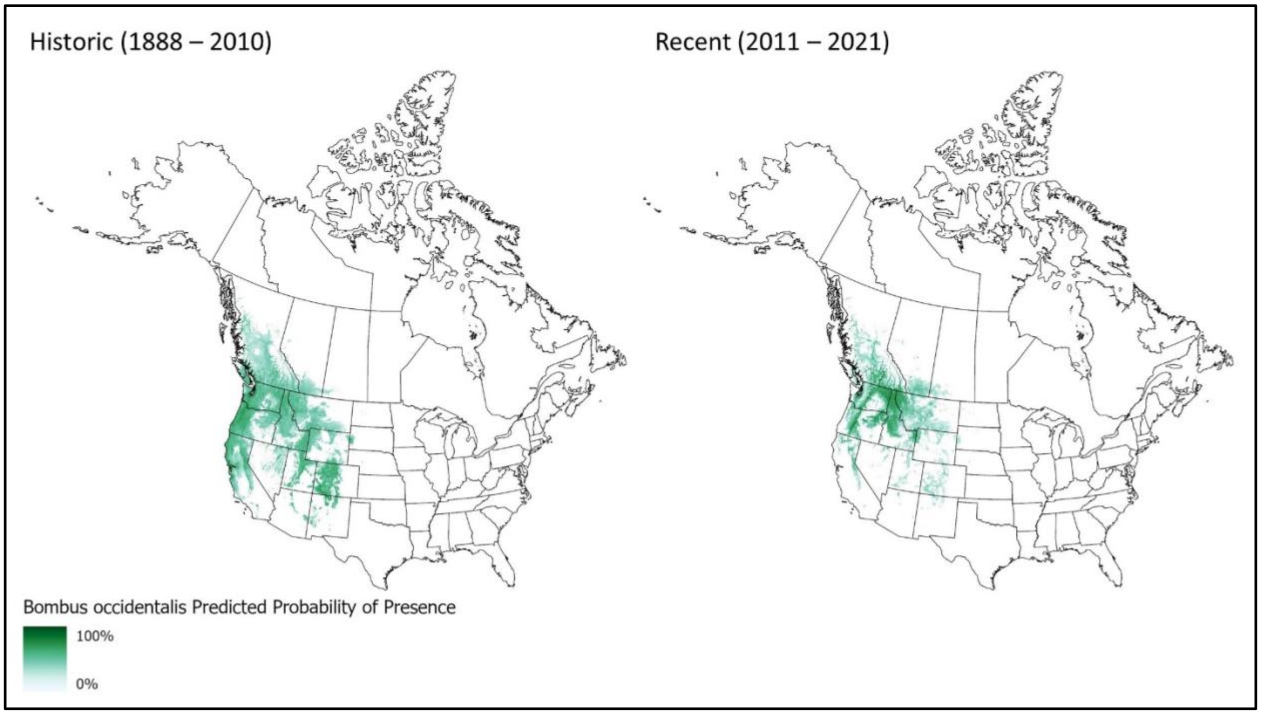


Figure A 10. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the western bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

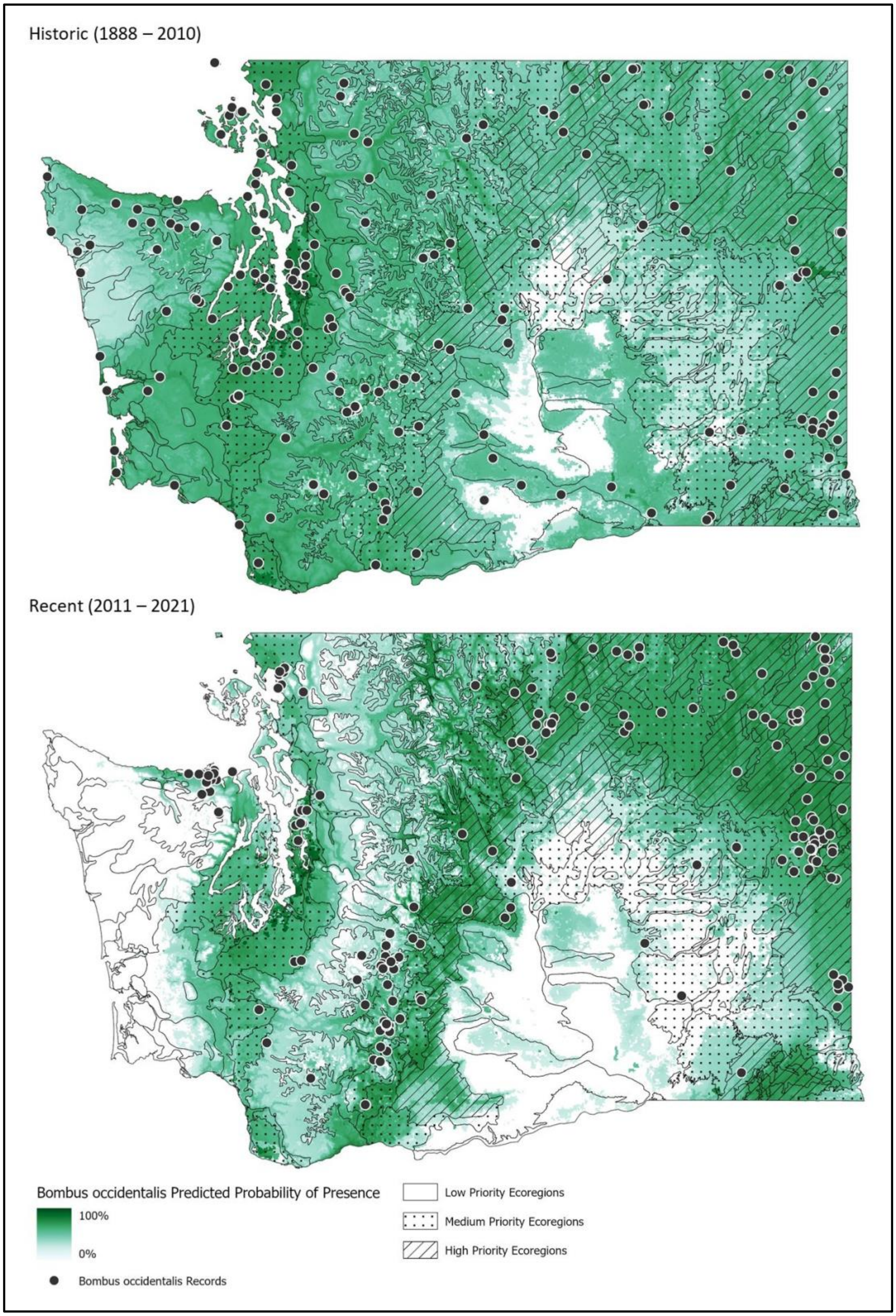


Figure A 11. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the western bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations

From the data available to us, historically (pre-2011), there are 639 records of this species in Washington, while recently (2011-2021) there are only 175 records. Historically, records were fairly broadly distributed throughout the state while recent records are located in the North Cascades and central eastern region of the state with a small cluster in the Puget lowlands where it was once common (Figure A 11, Table B 6).

Relative Abundance

Historic (pre-2011) relative abundance of this species in Washington state was 19.97% while recent (2011-2021) relative abundance is 3.64%. This represents a 81.76% decline in relative abundance. Range-wide analysis suggests that the western bumble bee has undergone a range decline of between 28% and 53% between recent and historic time periods (Hatfield et al. 2018, Cameron et al. 2011). Because the western bumble bee was divided into two subspecies (Williams et al. 2012) and then two separate species (Williams 2021) relatively recently, some of these range-wide analyses include both *B. occidentalis* as well as *B. mckayi*. See Table A 5 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the western bumble bee by land owner and land manager and Table B 6 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager

During the recent time period (2011-2021) the vast majority of occurrence records of this species were made on lands in the “other” category (92 records) and lands managed by the USFS (52 records) (Table A 5).

Based on the SDM in Washington state, the majority of the species’ predicted potential geographic distribution (52.57%) overlaps with lands managed by “other”, 29.71% overlaps with lands managed by the USFS, and each other land manager accounts for less than 4% of the species’ range (Table A 5).

Table A 5. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the western bumble bee by land owner and land manager in Washington.

Owner	**Manager**	**All Recent Occurrence Records**	**All Recent Occurrence Records of Focal Species**	**Relative Abundance of Focal Species**	***B. occidentalis* Recent Occurrence Records**	***B. occidentalis* Recent Relative Abundance**	**Percent *B. occidentalis* Predicted Potential Geographic Distribution Overlap**
Federal Government	US Forest Service	733	79	10.78%	52	7.09%	29.71%
Federal Government	US Bureau of Land Management	61	9	14.75%	1	1.64%	0.57%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	0	0.00%	0.00%
Federal Government	National Park Service	130	7	5.38%	4	3.08%	2.29%
Federal Government	US Bureau of Reclamation	11	2	18.18%	0	0.00%	0.00%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.00%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.00%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	4	2.42%	2.29%
State Government	WA Dept of Natural Resources	221	20	9.05%	6	2.71%	3.43%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	3	2.01%	1.71%
State Government	State University	67	14	20.90%	7	10.45%	4.00%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. occidentalis* Recent Occurrence Records	*B. occidentalis* Recent Relative Abundance	Percent *B. occidentalis* Predicted Potential Geographic Distribution Overlap
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	5	3.05%	2.86%
City, Municipal, or County Government	County	64	8	12.50%	1	1.56%	0.57%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	92	3.09%	52.57%

American Bumble Bee (*B. pensylvanicus*)

Left: Photo of the American bumble bee. Photo by Barbara Driscoll. Middle: Photo of the American bumble bee. Photo by Deborah Rudus. Right: Illustration of the American bumble bee. Illustrations by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

Distribution

The American bumble bee was historically found across much of the eastern US and occasionally in adjacent southern Ontario and Quebec. In the northern US most observations are from east of the Rockies (Figure A 12). Populations are also known from California and there are unconfirmed reports that it occurs in Oregon. The species is assessed as Vulnerable by the IUCN (Hatfield et al. 2015). A petition was submitted to the USFWS for the American bumble bee to be protected under the Endangered Species Act in February 2021, which resulted in a positive 90 day finding in September 2021 (USFWS 2022).

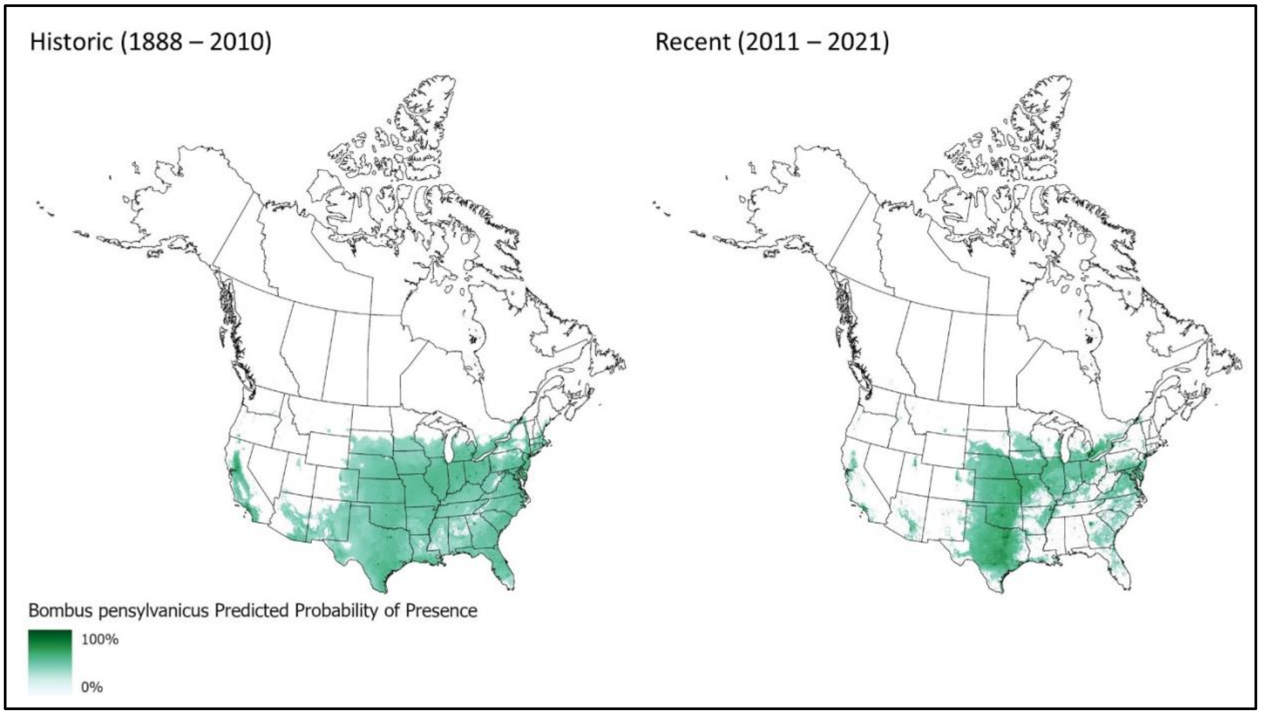


Figure A 12. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the American bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

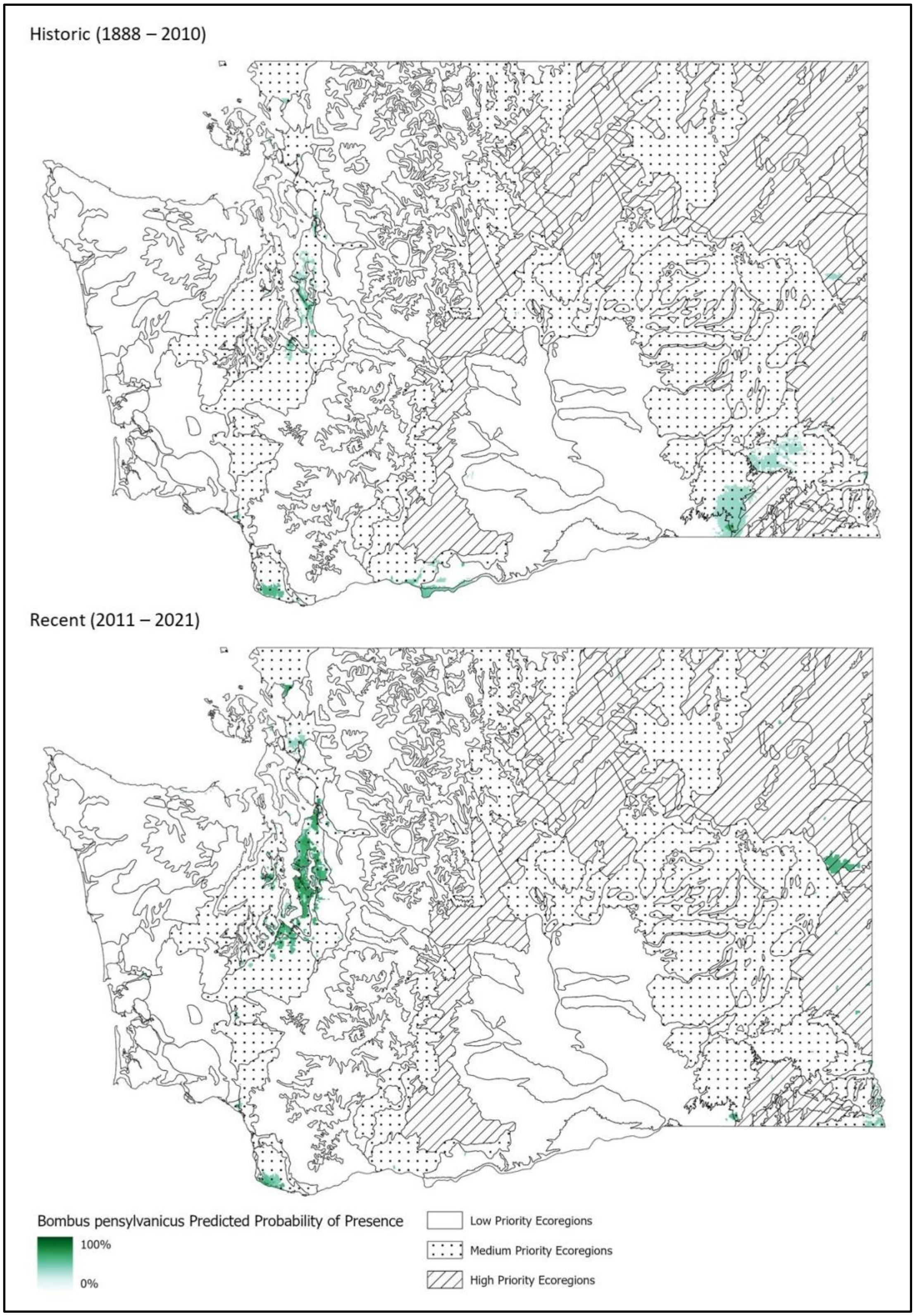


Figure A 13. Historic (pre-2011) (left) and recent (2011-2021) (right) predicted potential geographic distribution of the American bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area. Note that no records of this species were identified in Washington during the time period for the conservation assessment.

Recorded Observations

From the data available to us, there are no occurrence records of this species in Washington state during the time period analyzed for this conservation assessment (Figure A 13). More recently (in 2022), a single record of this species in Washington has been confirmed from June 2014. The occurrence record is from the Palouse Hills ecoregion in the southeastern region of the state.

Relative Abundance

This species record for the state of Washington was not confirmed until after this analysis was completed, so therefore the relative abundance is 0% for both the historic and recent time periods. See Table A 6 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the golden-belted bumble bee by land owner and land manager and Table B 7 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager

During the recent time period (2011-2021) no occurrences were recorded in the state of Washington (Table A 6).

Based on the SDM in Washington state, the majority of the species' predicted potential geographic distribution (90.08%) overlaps with lands managed by "other", 2.45% overlaps with lands managed by the National Park Service, 2.14% overlaps with lands managed by State Universities, and 2.04% overlaps with city or municipality property. The overlap between the species' predicted potential geographic distribution and any other land manager is less than 2.00% (Table A 6).

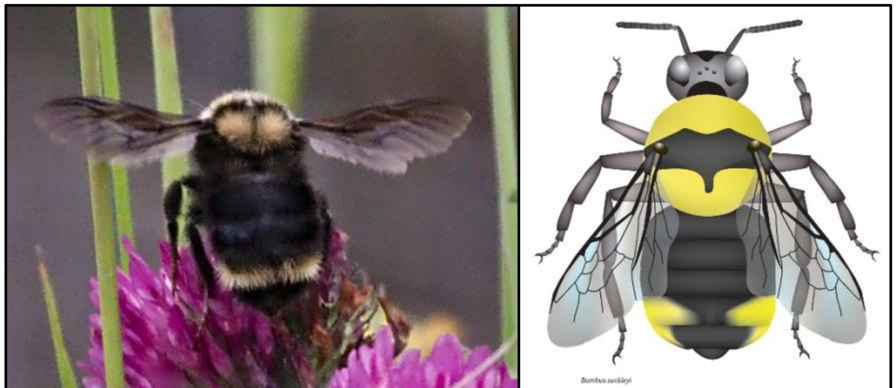
Table A 6. Occurrence records, relative abundance, and predicted potential geographic distribution overlap of the American bumble bee by land owner and land manager in Washington.

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. pensylvanicus* Recent Occurrence Records	*B. pensylvanicus* Recent Relative Abundance	Percent *B. pensylvanicus* Predicted Potential Geographic Distribution Overlap
Federal Government	US Forest Service	733	79	10.78%	0	0.00%	0.02%
Federal Government	US Bureau of Land Management	61	9	14.75%	0	0.00%	0.00%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	0	0.00%	1.04%
Federal Government	National Park Service	130	7	5.38%	0	0.00%	2.45%
Federal Government	US Bureau of Reclamation	11	2	18.18%	0	0.00%	0.00%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.06%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.31%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.39%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	0	0.00%	1.30%
State Government	WA Dept of Natural Resources	221	20	9.05%	0	0.00%	0.01%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	0	0.00%	0.69%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. pensylvanicus* Recent Occurrence Records	*B. pensylvanicus* Recent Relative Abundance	Percent *B. pensylvanicus* Predicted Potential Geographic Distribution Overlap
State Government	State University	67	14	20.90%	0	0.00%	2.14%
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.04%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	0	0.00%	2.04%
City, Municipal, or County Government	County	64	8	12.50%	0	0.00%	0.00%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	0	0.00%	90.08%

Suckley Cuckoo Bumble Bee (*B. suckleyi*)

Distribution



Left: Photo of the Suckley cuckoo bumble bee. Photo by Jack Bowling. Right: Illustration of the Suckley cuckoo bumble bee. Illustration by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

The Suckley cuckoo bumble bee is an imperiled species found from Alaska south through the Rocky Mountains to Colorado, and south in the Cascade and Klamath Mountains to northern California (Figure A 14). The bee also occurs in prairie habitats of Saskatchewan, Alberta, and Manitoba down through Nebraska. There is a disjunct population found in eastern Canada. The species is assessed as Critically Endangered by the IUCN (Hatfield et al. 2015). A petition was submitted to the USFWS for the Suckley cuckoo bumble bee to be protected under the Endangered Species Act in April 2020 (USFWS 2022). Petition findings have not yet been released.

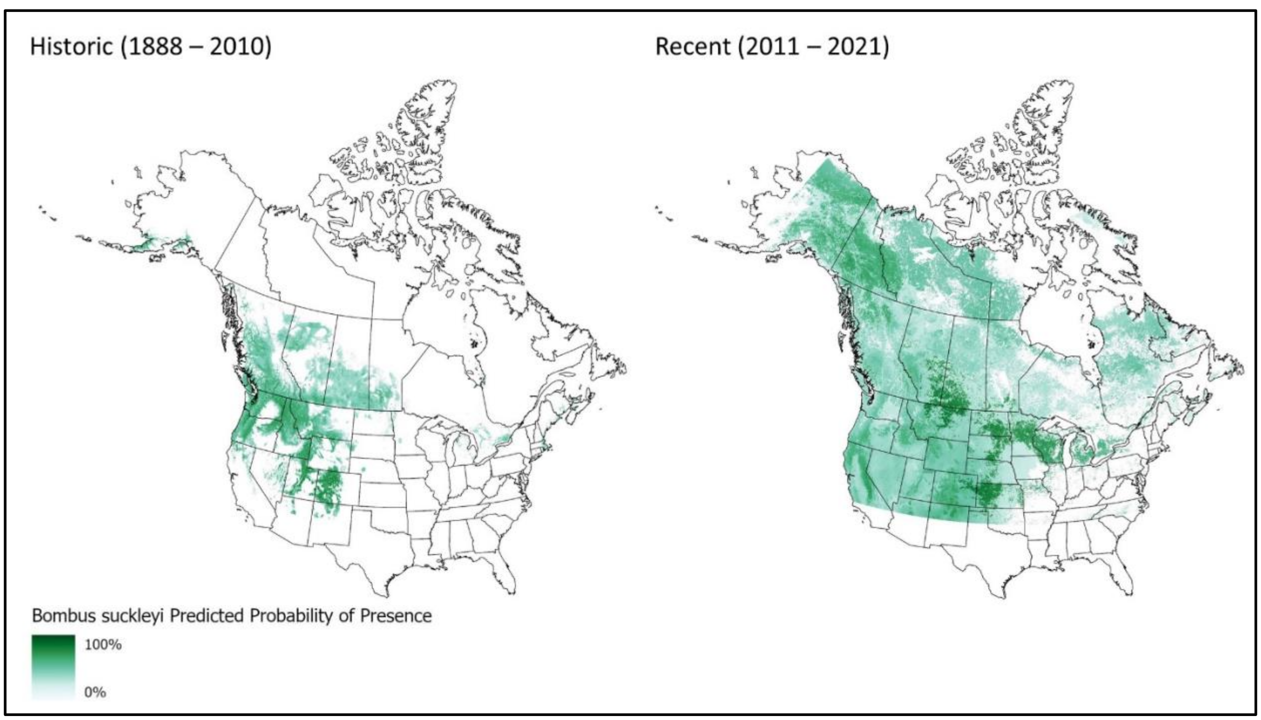


Figure A 14. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the Suckley cuckoo bumble bee in the US and Canada based on SDMs. predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

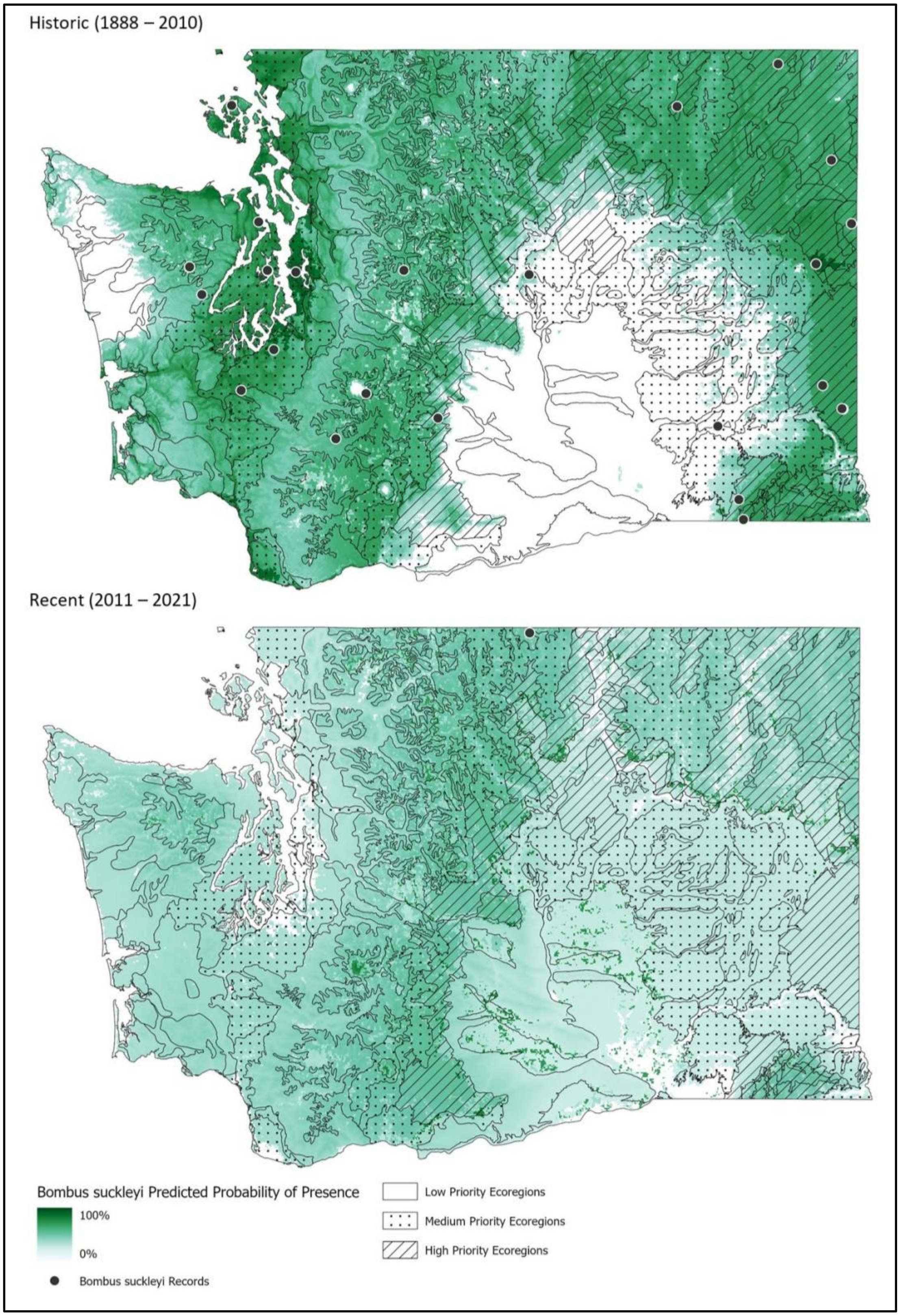


Figure A 15. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the Suckley cuckoo bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations
From the data available to us, historically (pre-2011), there are 39 records of this species in Washington, while recently (2011-2021) there is only a single record. Historic records were located in the Puget Lowlands, Central Cascades, and along the eastern edge of the state while the single recent record is located in the North Cascades near the Canadian border (Figure A 15).

Relative Abundance
Historic (pre-2011) relative abundance of this species in Washington state was 1.22% while recent (2011-2021) relative abundance is 0.02%. This represents a 98.36% decline in relative abundance. See Table A 7 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the Suckley cuckoo bumble bee by land owner and land manager and Table B 8 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager
During the recent time period (2011-2021) a single occurrence record of this species was made on lands managed by the USFS (0.14% of all occurrence records from lands managed by the USFS) (Table A 7).

Based on the SDM in Washington state, 100% of the species' predicted potential geographic distribution overlaps with lands managed by the USFS (Table A 7).

Table A 7. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the Suckley cuckoo bumble bee by land owner and land manager in Washington.

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. suckleyi* Recent Occurrence Records	*B. suckleyi* Recent Relative Abundance	Percent *B. suckleyi* Predicted Potential Geographic Distribution Overlap
Federal Government	US Forest Service	733	79	10.78%	1	0.14%	100.00%
Federal Government	US Bureau of Land Management	61	9	14.75%	0	0.00%	0.00%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	0	0.00%	0.00%
Federal Government	National Park Service	130	7	5.38%	0	0.00%	0.00%
Federal Government	US Bureau of Reclamation	11	2	18.18%	0	0.00%	0.00%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.00%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.00%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	0	0.00%	0.00%
State Government	WA Dept of Natural Resources	221	20	9.05%	0	0.00%	0.00%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	0	0.00%	0.00%
State Government	State University	67	14	20.90%	0	0.00%	0.00%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. suckleyi* Recent Occurrence Records	*B. suckleyi* Recent Relative Abundance	Percent *B. suckleyi* Predicted Potential Geographic Distribution Overlap
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	0	0.00%	0.00%
City, Municipal, or County Government	County	64	8	12.50%	0	0.00%	0.00%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	0	0.00%	0.00%

Half-black Bumble Bee (*B. vagans*)

Left: Photo of the half-black bumble bee. Photo by Eric Lee Mäder. Right: Illustration of the half-black bumble bee. Illustration by Paul Williams (identification and color patterns) and Elaine Evans (bee body design).

Distribution

The half-black bumble bee occurs mainly in the northeastern US and adjacent areas of Canada (Figure A 16). It is found throughout the Appalachian Mountains, and west through the Canadian prairie regions and into the upper elevations of the Pacific Northwest. In Washington, the species' range is mainly along the eastern foothills of the Cascades, north through the Okanagan Valley, east to the Selkirks, and south through the Spokane valley to the Blue Mountains.

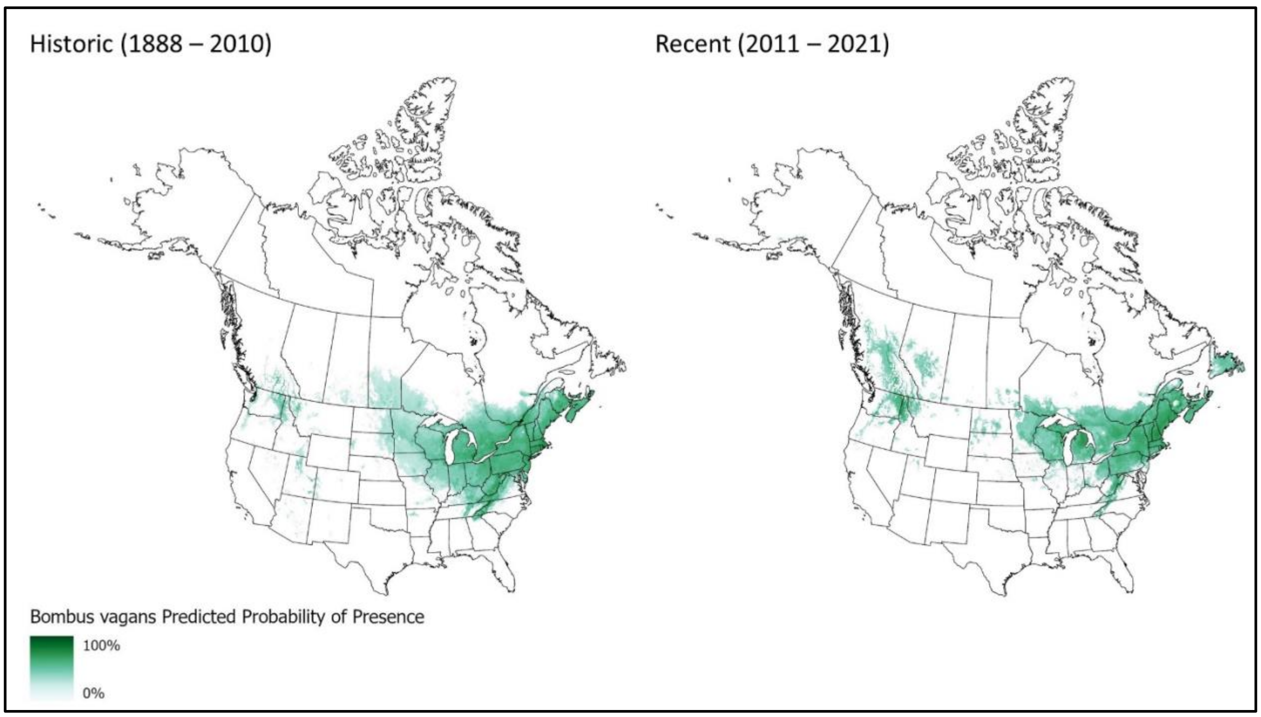


Figure A 16. The predicted potential historic (pre-2011) (left) and current (2011-2021) (right) geographic distribution of the half-black bumble bee in the US and Canada based on SDMs. Predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

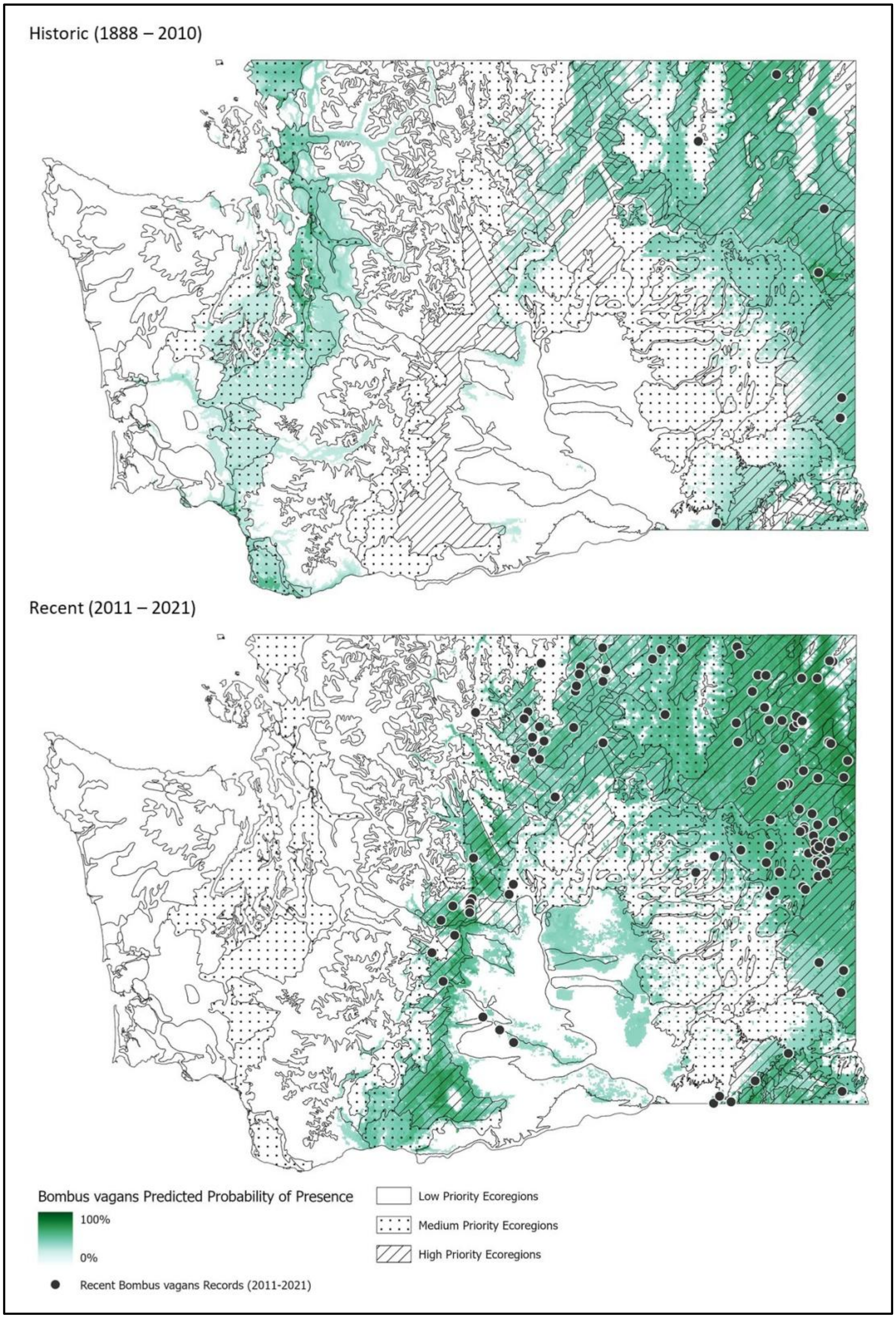


Figure A 17. Historic (pre-2011) (left) and recent (2011-2021) (right) occurrence records and predicted potential geographic distribution of the half-black bumble bee in Washington state. The predicted potential geographic distribution percentage indicates the probability of the species being present in any given area.

Recorded Observations

From the data available to us, historically (pre-2011), there are 18 records of this species in Washington, while recently (2011-2021) there are 87 records. Historically, occurrence records were from along the far eastern edge of the state while recent records are distributed in a horseshoe shape around the Columbia Plateau with a few records from within the Columbia Plateau (Figure A 17).

Relative Abundance

Historic (pre-2011) relative abundance of this species in Washington state was 0.56% while recent (2011-2021) relative abundance is 1.83%. This represents a 226.79% increase in relative abundance. See Table A 8 for occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the half-black bumble bee by land owner and land manager and Table B 9 for occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Distribution by Land Manager

During the recent time period (2011-2021) the vast majority of occurrence records (69 records) of this species were made on lands in the “other” category, followed by lands managed by WDFW (seven records), lands managed by DNR (four records), and County property (four records) (Table A 8). All other land managers accounted for two or fewer recent occurrence records.

Based on the SDM in Washington state, the majority of the species’ predicted potential geographic distribution (75.00%) overlaps with lands managed by “other”, 7.61% overlaps with lands managed by WDFW, 4.35% overlaps with lands managed by DNR, and 4.35% overlaps with county property (Table A 8). The overlap between this species’ predicted potential geographic distribution and any other land manager is less than 3.00%.

Table A 8. Occurrence records, relative abundance, and percent predicted potential geographic distribution overlap of the half-black bumble bee by land owner and land manager in Washington.

Owner	**Manager**	**All Recent Occurrence Records**	**All Recent Occurrence Records of Focal Species**	**Relative Abundance of Focal Species**	***B. vagans* Recent Occurrence Records**	***B. vagans* Recent Relative Abundance**	**Percent *B. vagans* Predicted Potential Geographic Distribution Overlap**
Federal Government	US Forest Service	733	79	10.78%	2	0.27%	2.17%
Federal Government	US Bureau of Land Management	61	9	14.75%	1	1.64%	1.09%
Federal Government	US Fish and Wildlife Service	66	5	7.58%	1	1.52%	1.09%
Federal Government	National Park Service	130	7	5.38%	1	0.77%	1.09%
Federal Government	US Bureau of Reclamation	11	2	18.18%	1	9.09%	1.09%
Federal Government	US Department of Energy	0	0	NA	0	NA	0.00%
Federal Government	US Dept of Defense	20	4	20.00%	0	0.00%	0.00%
Federal Government	Army Corps of Engineers	8	2	25.00%	0	0.00%	0.00%
State Government	WA Dept of Fish and Wildlife	165	26	15.76%	7	4.24%	7.61%
State Government	WA Dept of Natural Resources	221	20	9.05%	4	1.81%	4.35%
State Government	WA State Parks and Recreation Commission	149	8	5.37%	0	0.00%	0.00%
State Government	State University	67	14	20.90%	0	0.00%	0.00%

Owner	Manager	All Recent Occurrence Records	All Recent Occurrence Records of Focal Species	Relative Abundance of Focal Species	*B. vagans* Recent Occurrence Records	*B. vagans* Recent Relative Abundance	Percent *B. vagans* Predicted Potential Geographic Distribution Overlap
State Government	WA Dept of Corrections	0	0	NA	0	NA	0.00%
State Government	WA Dept of Social and Health Services	1	0	0.00%	0	0.00%	0.00%
City, Municipal, or County Government	City or Municipality	164	25	15.24%	2	1.22%	2.17%
City, Municipal, or County Government	County	64	8	12.50%	4	6.25%	4.35%
Other (Private or Tribal)	Other (Private or Tribal)	2975	344	11.56%	69	2.32%	75.00%

Appendix B: Figures and Tables

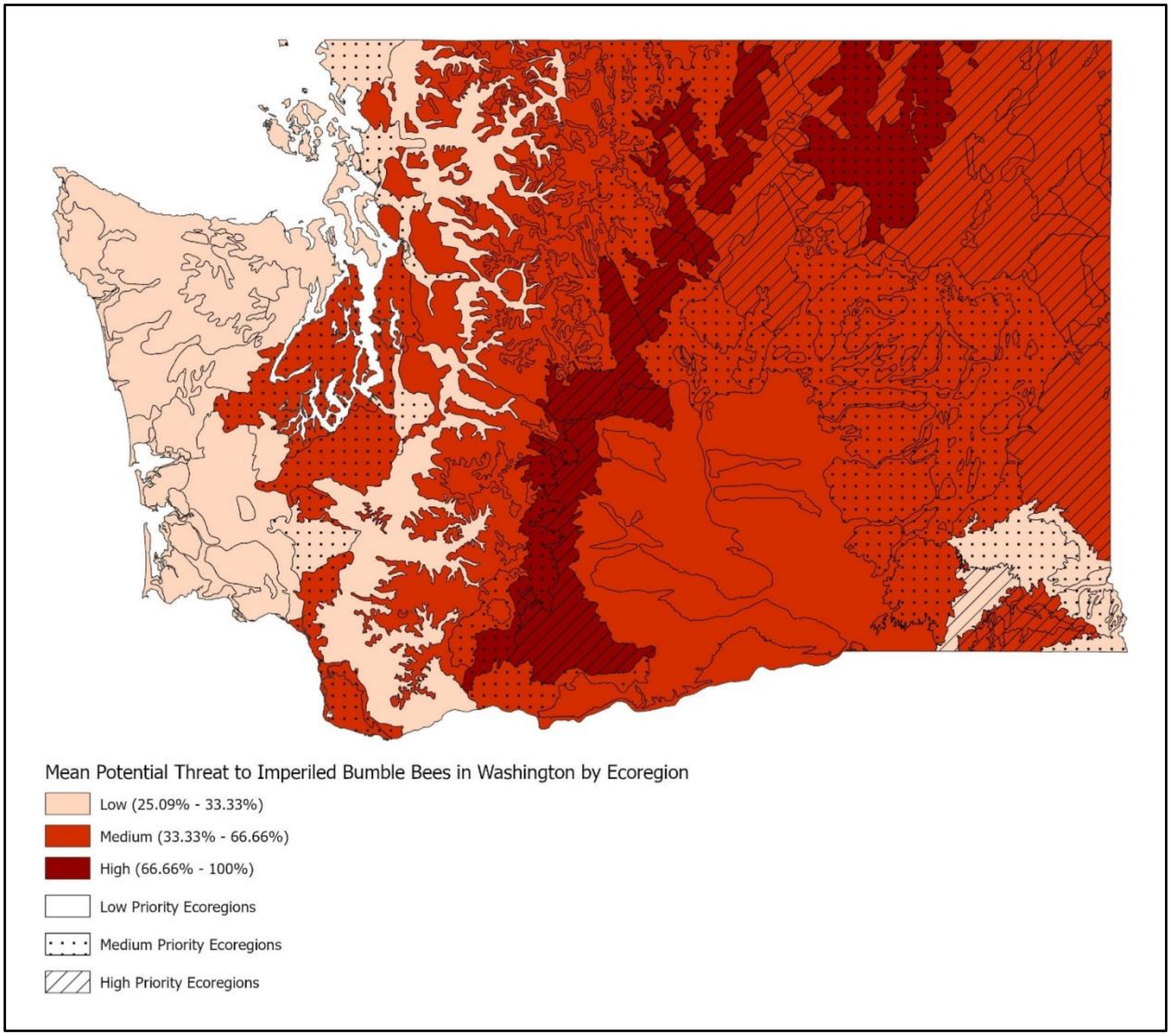


Figure B 1. Average potential threat within level IV ecoregions of Washington. The average potential threat score combines threat scores for agriculture and development, grazing, wildfire, pesticides, and climate change.

Table B 1. Occurrence records and relative abundance of all focal species in the state of Washington.

Species	Number of Recent Occurrences (2011-2021)	Total Recent Occurrences of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Occurrences (pre-2011)	Total Historic Occurrences of all Species (pre-2011)	Historic Relative Abundance (pre-2011)	Change in Relative Abundance
B. fervidus	268	4750	5.64%	313	3201	9.78%	-42.33%
B. frigidus	2	4750	0.04%	2	3201	0.06%	-33.33%
B. kirbiellus	4	4750	0.08%	1	3201	0.03%	166.67%
B. morrisoni	6	4750	0.13%	32	3201	1.00%	-87.00%
B. occidentalis	173	4750	3.64%	639	3201	19.96%	-81.76%
B. pensylvanicus	0	4750	0.00%	0	3201	0.00%	0.00%
B. suckleyi	1	4750	0.02%	39	3201	1.22%	-98.36%
B. vagans	87	4750	1.83%	18	3201	0.56%	226.79%

Table B 2. Yellow bumble bee (*B. fervidus*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	1	24	4.17%	0	1	0.00%	NA
Cascade Subalpine/ Alpine	0	86	0.00%	0	46	0.00%	NA
Central Puget Lowland	117	1107	10.57%	35	478	7.32%	44.40%
Channeled Scablands	21	381	5.51%	9	79	11.39%	-51.62%
Chelan Tephra Hills	0	20	0.00%	2	6	33.33%	-100.00%
Chiwaukum Hills and Lowlands	1	76	1.32%	0	32	0.00%	NA
Coastal Lowlands	5	50	10.00%	4	75	5.33%	87.62%
Coastal Uplands	1	33	3.03%	1	51	1.96%	54.59%
Cowlitz/ Chehalis Foothills	1	9	11.11%	1	6	16.67%	-33.35%

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Cowlitz/ Newaukum Prairie Floodplains	0	9	0.00%	3	6	50.00%	-100.00%
Deep Loess Foothills	2	7	0.00%	0	2	0.00%	NA
Dissected Loess Uplands	1	20	5.00%	1	14	7.14%	-29.97%
Eastern Puget Riverine Lowlands	4	68	5.88%	4	31	12.9%	-54.42%
Eastern Puget Uplands	13	176	7.39%	3	40	7.50%	-1.47%
Fraser Lowland	1	113	0.88%	1	28	3.57%	-75.35%
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Olympics	0	37	0.00%	2	46	4.35%	-100.00%
Inland Maritime Foothills and Valleys	0	24	0.00%	0	1	0.00%	NA
Loess Islands	3	33	9.09%	0	6	0.00%	NA
High Northern Rockies	0	0	NA	0	0	NA	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Low Olympics	0	50	0.00%	1	30	3.33%	-100.00%
Lower Snake and Clearwater Canyons	1	14	7.14%	16	66	24.24%	-70.54%
Maritime-Influenced Zone	0	2	0.00%	0	5	0.00%	NA
Mesic Forest Zone	2	14	14.29%	0	10	0.00%	NA
North Cascades Highland Forests	1	87	1.15%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	1	28	3.57%	-100.00%
North Cascades Subalpine/ Alpine	0	117	0.00%	1	31	3.23%	-100.00%
Northern Idaho Hills and Low Relief Mountains	0	22	0.00%	0	1	0.00%	NA
Oak/Conifer Foothills	8	42	19.05%	1	7	14.29%	33.31%
Okanogan Drift Hills	2	14	14.29%	0	0	NA	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	1	56	1.79%	1	51	1.96%	-8.67%
Okanogan Valley	10	111	9.01%	1	11	9.09%	-0.88%
Okanogan-Colville Xeric Valleys and Foothills	0	76	0.00%	0	56	0.00%	NA
Olympic Rainshadow	3	256	1.17%	14	66	21.21%	-94.48%
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	3	105	2.86%	113	879	12.86%	-77.76%
Pasayten/ Sawtooth Highlands	1	50	2.00%	0	34	0.00%	NA
Pleistocene Lake Basins	11	191	5.76%	48	198	24.24%	-76.24%
Portland/ Vancouver Basin	5	100	5.00%	1	11	9.09%	-44.99%
San Juan Islands	0	91	0.00%	8	129	6.20%	-100.00%
Selkirk Mountains	1	33	3.03%	0	28	0.00%	NA
Southern Puget Prairies	17	210	8.10%	23	187	12.30%	-34.15%

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Spokane Valley Outwash Plains	4	162	2.47%	0	40	0.00%	NA
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	1	18	5.56%	0	1	0.00%	NA
Volcanics	0	55	0.00%	1	53	1.89%	-100.00%
Wenatchee/ Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	9	85	10.59%	2	65	3.08%	243.83%
Western Cascades Montane Highlands	1	55	1.82%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	1	14	7.14%	-100.00%
Yakima Folds	18	133	13.53%	11	30	36.67%	-63.10%

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Yakima Plateau and Slopes	0	74	0.00%	3	27	11.11%	-100.00%

Table B 3. Frigid bumble bee (*B. frigidus*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	0	24	0.00%	0	1	0.00%	NA
Cascade Subalpine/Alpine	0	86	0.00%	0	46	0.00%	NA
Central Puget Lowland	0	1107	0.00%	0	478	0.00%	NA
Channeled Scablands	0	381	0.00%	0	79	0.00%	NA
Chelan Tephra Hills	0	20	0.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	0	76	0.00%	0	32	0.00%	NA
Coastal Lowlands	0	50	0.00%	0	75	0.00%	NA
Coastal Uplands	0	33	0.00%	0	51	0.00%	NA
Cowlitz/Chehalis Foothills	0	9	0.00%	0	6	0.00%	NA
Cowlitz/Newaukum Prairie Floodplains	0	9	0.00%	0	6	0.00%	NA
Deep Loess Foothills	2	7	0.00%	0	2	0.00%	NA
Dissected Loess Uplands	0	20	0.00%	0	14	0.00%	NA
Eastern Puget Riverine Lowlands	0	68	0.00%	0	31	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Uplands	0	176	0.00%	0	40	0.00%	NA
Fraser Lowland	0	113	0.00%	0	28	0.00%	NA
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Northern Rockies	0	0	NA	0	0	NA	NA
High Olympics	0	37	0.00%	1	46	2.17%	-100.00%
Inland Maritime Foothills and Valleys	0	24	0.00%	0	1	0.00%	NA
Loess Islands	0	33	0.00%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	0	30	0.00%	NA
Lower Snake and Clearwater Canyons	0	14	0.00%	0	66	0.00%	NA
Maritime-Influenced Zone	0	2	0.00%	0	5	0.00%	NA
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	1	87	1.15%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	0	28	0.00%	NA
North Cascades Subalpine/Alpine	1	117	0.85%	0	31	0.00%	NA
Northern Idaho Hills and Low Relief Mountains	0	22	0.00%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	0	7	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	0	56	0.00%	0	51	0.00%	NA
Okanogan Valley	0	111	0.00%	0	11	0.00%	NA
Okanogan-Colville Xeric Valleys and Foothills	0	76	0.00%	0	56	0.00%	NA
Olympic Rainshadow	0	256	0.00%	0	66	0.00%	NA
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	0	105	0.00%	0	879	0.00%	NA
Pasayten/Sawtooth Highlands	0	50	0.00%	0	34	0.00%	NA
Pleistocene Lake Basins	0	191	0.00%	0	198	0.00%	NA
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	0	129	0.00%	NA
Selkirk Mountains	0	33	0.00%	0	28	0.00%	NA
Southern Puget Prairies	0	210	0.00%	0	187	0.00%	NA
Spokane Valley Outwash Plains	0	162	0.00%	0	40	0.00%	NA
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Volcanics	0	55	0.00%	0	53	0.00%	NA
Wenatchee/Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	0	85	0.00%	0	65	0.00%	NA
Western Cascades Montane Highlands	0	55	0.00%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	0	14	0.00%	NA
Yakima Folds	0	133	0.00%	0	30	0.00%	NA
Yakima Plateau and Slopes	0	74	0.00%	0	27	0.00%	NA

Table B 4. Golden-belted bumble bee (*B. kirbiellus*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	0	24	0.00%	0	1	0.00%	NA
Cascade Subalpine/Alpine	0	86	0.00%	0	46	0.00%	NA
Central Puget Lowland	0	1107	0.00%	0	478	0.00%	NA
Channeled Scablands	0	381	0.00%	0	79	0.00%	NA
Chelan Tephra Hills	0	20	0.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	0	76	0.00%	0	32	0.00%	NA
Coastal Lowlands	0	50	0.00%	0	75	0.00%	NA
Coastal Uplands	0	33	0.00%	0	51	0.00%	NA
Cowlitz/Chehalis Foothills	0	9	0.00%	0	6	0.00%	NA
Cowlitz/Newaukum Prairie Floodplains	0	9	0.00%	0	6	0.00%	NA
Deep Loess Foothills	2	7	0.00%	0	2	0.00%	NA
Dissected Loess Uplands	0	20	0.00%	0	14	0.00%	NA
Eastern Puget Riverine Lowlands	0	68	0.00%	0	31	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Uplands	0	176	0.00%	0	40	0.00%	NA
Fraser Lowland	0	113	0.00%	0	28	0.00%	NA
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Northern Rockies	0	0	NA	0	0	NA	NA
High Olympics	0	37	0.00%	0	46	0.00%	NA
Inland Maritime Foothills and Valleys	0	24	0.00%	0	1	0.00%	NA
Loess Islands	0	33	0.00%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	0	30	0.00%	NA
Lower Snake and Clearwater Canyons	0	14	0.00%	0	66	0.00%	NA
Maritime-Influenced Zone	0	2	0.00%	0	5	0.00%	NA
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	0	87	0.00%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	0	28	0.00%	NA
North Cascades Subalpine/Alpine	3	117	2.56%	1	31	3.23%	-20.74%
Northern Idaho Hills and Low Relief Mountains	0	22	0.00%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	0	7	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	0	56	0.00%	0	51	0.00%	NA
Okanogan Valley	0	111	0.00%	0	11	0.00%	NA
Okanogan-Colville Xeric Valleys and Foothills	0	76	0.00%	0	56	0.00%	NA
Olympic Rainshadow	0	256	0.00%	0	66	0.00%	NA
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	0	105	0.00%	0	879	0.00%	NA
Pasayten/Sawtooth Highlands	1	50	2.00%	0	34	0.00%	NA
Pleistocene Lake Basins	0	191	0.00%	0	198	0.00%	NA
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	0	129	0.00%	NA
Selkirk Mountains	0	33	0.00%	0	28	0.00%	NA
Southern Puget Prairies	0	210	0.00%	0	187	0.00%	NA
Spokane Valley Outwash Plains	0	162	0.00%	0	40	0.00%	NA
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Volcanics	0	55	0.00%	0	53	0.00%	NA
Wenatchee/Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	0	85	0.00%	0	65	0.00%	NA
Western Cascades Montane Highlands	0	55	0.00%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	0	14	0.00%	NA
Yakima Folds	0	133	0.00%	0	30	0.00%	NA
Yakima Plateau and Slopes	0	74	0.00%	0	27	0.00%	NA

Table B 5. Morrison bumble bee (*B. morrisoni*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	0	24	0.00%	0	1	0.00%	NA
Cascade Subalpine/Alpine	0	86	0.00%	0	46	0.00%	NA
Central Puget Lowland	0	1107	0.00%	0	478	0.00%	NA
Channeled Scablands	1	381	0.26%	3	79	3.80%	-93.16%
Chelan Tephra Hills	1	20	5.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	0	76	0.00%	0	32	0.00%	NA
Coastal Lowlands	1	50	2.00%	0	75	0.00%	NA
Coastal Uplands	0	33	0.00%	0	51	0.00%	NA
Cowlitz/Chehalis Foothills	0	9	0.00%	0	6	0.00%	NA
Cowlitz/Newaukum Prairie Floodplains	0	9	0.00%	0	6	0.00%	NA
Deep Loess Foothills	2	7	0.00%	0	2	0.00%	NA
Dissected Loess Uplands	0	20	0.00%	0	14	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Riverine Lowlands	0	68	0.00%	0	31	0.00%	NA
Eastern Puget Uplands	0	176	0.00%	0	40	0.00%	NA
Fraser Lowland	0	113	0.00%	0	28	0.00%	NA
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Northern Rockies	0	0	NA	0	0	NA	NA
High Olympics	0	37	0.00%	0	46	0.00%	NA
Inland Maritime Foothills and Valleys	0	24	0.00%	0	1	0.00%	NA
Loess Islands	0	33	0.00%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	0	30	0.00%	NA
Lower Snake and Clearwater Canyons	0	14	0.00%	0	66	0.00%	NA
Maritime-Influenced Zone	0	2	0.00%	1	5	20.00%	-100.00%
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	0	87	0.00%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	0	28	0.00%	NA
North Cascades Subalpine/Alpine	0	117	0.00%	0	31	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Northern Idaho Hills and Low Relief Mountains	0	22	0.00%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	0	7	0.00%	NA
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	0	56	0.00%	0	51	0.00%	NA
Okanogan Valley	0	111	0.00%	0	11	0.00%	NA
Okanogan-Colville Xeric Valleys and Foothills	0	76	0.00%	0	56	0.00%	NA
Olympic Rainshadow	0	256	0.00%	0	66	0.00%	NA
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	1	105	0.95%	3	879	0.34%	179.41%
Pasayten/Sawtooth Highlands	0	50	0.00%	0	34	0.00%	NA
Pleistocene Lake Basins	2	191	1.05%	24	198	12.12%	-91.34%
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	0	129	0.00%	NA
Selkirk Mountains	0	33	0.00%	0	28	0.00%	NA
Southern Puget Prairies	0	210	0.00%	0	187	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Spokane Valley Outwash Plains	0	162	0.00%	1	40	2.50%	-100.00%
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA
Volcanics	0	55	0.00%	0	53	0.00%	NA
Wenatchee/Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	0	85	0.00%	0	65	0.00%	NA
Western Cascades Montane Highlands	0	55	0.00%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	0	14	0.00%	NA
Yakima Folds	0	133	0.00%	0	30	0.00%	NA
Yakima Plateau and Slopes	0	74	0.00%	0	27	0.00%	NA

Table B 6. Western bumble bee (*B. occidentalis*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	3	17	17.65%	-100.00%
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	5	24	20.83%	1	1	100.00%	-79.17%
Cascade Subalpine/Alpine	13	86	15.12%	7	46	15.22%	-0.66
Central Puget Lowland	13	1107	1.17%	170	478	35.56%	-96.71%
Channeled Scablands	7	381	1.84%	23	79	29.11%	-93.68%
Chelan Tephra Hills	0	20	0.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	3	76	3.95%	1	32	3.12%	26.60%
Coastal Lowlands	0	50	0.00%	7	75	9.33%	-100.00%
Coastal Uplands	0	33	0.00%	6	51	11.76%	-100.00%
Cowlitz/Chehalis Foothills	0	9	0.00%	1	6	16.67%	-100.00%
Cowlitz/Newaukum Prairie Floodplains	1	9	11.11%	2	6	33.33%	-66.67%
Deep Loess Foothills	2	7	14.29%	1	2	50.00%	-71.42%
Dissected Loess Uplands	0	20	0.00%	3	14	21.43%	-100.00%
Eastern Puget Riverine Lowlands	0	68	0.00%	2	31	6.45%	-100.00%

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Uplands	3	176	1.70%	11	40	27.50%	-93.82%
Fraser Lowland	5	113	4.42%	7	28	25.00%	-82.32%
Grand Fir Mixed Forest	3	69	4.35%	6	19	31.58%	-86.23%
High Northern Rockies	0	0	NA	0	0	NA	NA
High Olympics	4	37	10.81%	8	46	17.39%	-37.84%
Inland Maritime Foothills and Valleys	6	24	25.00%	0	1	0.00%	NA
Loess Islands	4	33	12.12%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	6	30	20.00%	-100.00%
Lower Snake and Clearwater Canyons	0	14	0.00%	7	66	10.61%	-100.00%
Maritime-Influenced Zone	0	2	0.00%	0	5	0.00%	NA
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	1	87	1.15%	0	36	0.00%	NA
North Cascades Lowland Forests	1	51	1.96%	3	28	10.71%	-81.70%
North Cascades Subalpine/Alpine	1	117	0.85%	6	31	19.35%	-95.61%
Northern Idaho Hills and Low Relief Mountains	4	22	18.18%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	4	7	57.14%	-100.00%

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	3	24	12.50%	4	47	8.51%	46.89%
Okanogan Pine/Fir Hills	5	56	8.93%	2	51	3.92%	127.81%
Okanogan Valley	2	111	1.80%	1	11	9.09%	-80.20%
Okanogan-Colville Xeric Valleys and Foothills	5	76	6.58%	9	56	16.07%	-59.05%
Olympic Rainshadow	27	256	10.55%	5	66	7.58%	39.18%
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	8	105	7.62%	172	879	19.57%	-61.06%
Pasayten/Sawtooth Highlands	3	50	6.00%	1	34	2.94%	104.08%
Pleistocene Lake Basins	1	191	0.52%	27	198	13.64%	-96.19%
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	31	129	24.03%	-100.00%
Selkirk Mountains	6	33	18.18%	5	28	17.86%	1.79%
Southern Puget Prairies	2	210	0.95%	29	187	15.51%	-93.87%
Spokane Valley Outwash Plains	18	162	11.11%	8	40	20.00%	-44.45%
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Volcanics	0	55	0.00%	9	53	16.98%	-100.00%
Wenatchee/Chelan Highlands	0	20	0.00%	3	22	13.64%	-100.00%
Western Cascades Lowlands and Valleys	2	85	2.35%	27	65	41.54%	-94.34%
Western Cascades Montane Highlands	10	55	18.18%	6	39	15.38%	18.21%
Western Okanogan Semiarid Foothills	2	10	20.00%	4	5	80.00%	-75.00%
Western Selkirk Maritime Forest	1	13	7.69%	3	7	42.86%	-82.06%
Willapa Hills	0	38	0.00%	4	14	28.57%	-100.00%
Yakima Folds	0	133	0.00%	1	30	3.33%	-100.00%
Yakima Plateau and Slopes	3	74	4.05%	3	27	11.11%	-63.55%

Table B 7. American bumble bee (*B. pensylvanicus*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	0	24	0.00%	0	1	0.00%	NA
Cascade Subalpine/Alpine	0	86	0.00%	0	46	0.00%	NA
Central Puget Lowland	0	1107	0.00%	0	478	0.00%	NA
Channeled Scablands	0	381	0.00%	0	79	0.00%	NA
Chelan Tephra Hills	0	20	0.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	0	76	0.00%	0	32	0.00%	NA
Coastal Lowlands	0	50	0.00%	0	75	0.00%	NA
Coastal Uplands	0	33	0.00%	0	51	0.00%	NA
Cowlitz/Chehalis Foothills	0	9	0.00%	0	6	0.00%	NA
Cowlitz/Newaukum Prairie Floodplains	0	9	0.00%	0	6	0.00%	NA
Deep Loess Foothills	0	7	0.00%	0	2	0.00%	NA
Dissected Loess Uplands	0	20	0.00%	0	14	0.00%	NA
Eastern Puget Riverine Lowlands	0	68	0.00%	0	31	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Uplands	0	176	0.00%	0	40	0.00%	NA
Fraser Lowland	0	113	0.00%	0	28	0.00%	NA
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Northern Rockies	0	0	0.00%	0	0	NA	NA
High Olympics	0	37	0.00%	0	46	0.00%	NA
Inland Maritime Foothills and Valleys	0	24	0.00%	0	1	0.00%	NA
Loess Islands	0	33	0.00%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	0	30	0.00%	NA
Lower Snake and Clearwater Canyons	0	14	0.00%	0	66	0.00%	NA
Maritime-Influenced Zone	0	2	0.00%	0	5	0.00%	NA
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	0	87	0.00%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	0	28	0.00%	NA
North Cascades Subalpine/Alpine	0	117	0.00%	0	31	0.00%	NA
Northern Idaho Hills and Low Relief Mountains	0	22	0.00%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	0	7	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	0	56	0.00%	0	51	0.00%	NA
Okanogan Valley	0	111	0.00%	0	11	0.00%	NA
Okanogan-Colville Xeric Valleys and Foothills	0	76	0.00%	0	56	0.00%	NA
Olympic Rainshadow	0	256	0.00%	0	66	0.00%	NA
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	0	105	0.00%	0	879	0.00%	NA
Pasayten/Sawtooth Highlands	0	50	0.00%	0	34	0.00%	NA
Pleistocene Lake Basins	0	191	0.00%	0	198	0.00%	NA
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	0	129	0.00%	NA
Selkirk Mountains	0	33	0.00%	0	28	0.00%	NA
Southern Puget Prairies	0	210	0.00%	0	187	0.00%	NA
Spokane Valley Outwash Plains	0	162	0.00%	0	40	0.00%	NA
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Volcanics	0	55	0.00%	0	53	0.00%	NA
Wenatchee/Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	0	85	0.00%	0	65	0.00%	NA
Western Cascades Montane Highlands	0	55	0.00%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	0	14	0.00%	NA
Yakima Folds	0	133	0.00%	0	30	0.00%	NA
Yakima Plateau and Slopes	0	74	0.00%	0	27	0.00%	NA

Table B 8. Suckley cuckoo bumble bee (*B. suckleyi*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	0	24	0.00%	0	1	0.00%	NA
Cascade Subalpine/Alpine	0	86	0.00%	1	46	2.17%	-100.00%
Central Puget Lowland	0	1107	0.00%	21	478	4.39%	-100.00%
Channeled Scablands	0	381	0.00%	1	79	1.27%	-100.00%
Chelan Tephra Hills	0	20	0.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	0	76	0.00%	0	32	0.00%	NA
Coastal Lowlands	0	50	0.00%	0	75	0.00%	NA
Coastal Uplands	0	33	0.00%	0	51	0.00%	NA
Cowlitz/Chehalis Foothills	0	9	0.00%	0	6	0.00%	NA
Cowlitz/Newaukum Prairie Floodplains	0	9	0.00%	0	6	0.00%	NA
Deep Loess Foothills	2	7	0.00%	1	2	50.00%	-100.00%
Dissected Loess Uplands	0	20	0.00%	0	14	0.00%	NA
Eastern Puget Riverine Lowlands	0	68	0.00%	0	31	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Uplands	0	176	0.00%	0	40	0.00%	NA
Fraser Lowland	0	113	0.00%	0	28	0.00%	NA
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Northern Rockies	0	0	NA	0	0	NA	NA
High Olympics	0	37	0.00%	1	46	2.17%	-100.00%
Inland Maritime Foothills and Valleys	0	24	0.00%	1	1	100.00%	-100.00%
Loess Islands	0	33	0.00%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	0	30	0.00%	NA
Lower Snake and Clearwater Canyons	0	14	0.00%	0	66	0.00%	NA
Maritime-Influenced Zone	0	2	0.00%	0	5	0.00%	NA
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	0	87	0.00%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	0	28	0.00%	NA
North Cascades Subalpine/Alpine	1	117	0.85%	0	31	0.00%	NA
Northern Idaho Hills and Low Relief Mountains	0	22	0.00%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	0	7	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	0	56	0.00%	0	51	0.00%	NA
Okanogan Valley	0	111	0.00%	0	11	0.00%	NA
Okanogan-Colville Xeric Valleys and Foothills	0	76	0.00%	0	56	0.00%	NA
Olympic Rainshadow	0	256	0.00%	0	66	0.00%	NA
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	0	105	0.00%	4	879	0.46%	-100.00%
Pasayten/Sawtooth Highlands	0	50	0.00%	0	34	0.00%	NA
Pleistocene Lake Basins	0	191	0.00%	0	198	0.00%	NA
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	1	129	0.78%	-100.00%
Selkirk Mountains	0	33	0.00%	0	28	0.00%	NA
Southern Puget Prairies	0	210	0.00%	2	187	1.07%	-100.00%
Spokane Valley Outwash Plains	0	162	0.00%	1	40	2.50%	-100.00%
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Volcanics	0	55	0.00%	3	53	5.66%	-100.00%
Wenatchee/Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	0	85	0.00%	1	65	1.54%	-100.00%
Western Cascades Montane Highlands	0	55	0.00%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	0	14	0.00%	NA
Yakima Folds	0	133	0.00%	0	30	0.00%	NA
Yakima Plateau and Slopes	0	74	0.00%	1	27	3.70%	-100.00%

Table B 9. Half-black bumble bee (*B. vagans*) occurrence records, relative abundance, and mean predicted probability of presence by level IV ecoregion for recent (2011-2021) and historic (pre-2011) time periods.

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Canyons and Dissected Highlands	0	15	0.00%	0	17	0.00%	NA
Canyons and Dissected Uplands	0	3	0.00%	0	2	0.00%	NA
Cascade Crest Montane Forest	0	24	0.00%	0	1	0.00%	NA
Cascade Subalpine/Alpine	0	86	0.00%	0	46	0.00%	NA
Central Puget Lowland	0	1107	0.00%	0	478	0.00%	NA
Channeled Scablands	15	381	3.94%	0	79	0.00%	NA
Chelan Tephra Hills	0	20	0.00%	0	6	0.00%	NA
Chiwaukum Hills and Lowlands	4	76	5.26%	0	32	0.00%	NA
Coastal Lowlands	0	50	0.00%	0	75	0.00%	NA
Coastal Uplands	0	33	0.00%	0	51	0.00%	NA
Cowlitz/Chehalis Foothills	0	9	0.00%	0	6	0.00%	NA
Cowlitz/Newaukum Prairie Floodplains	0	9	0.00%	0	6	0.00%	NA
Deep Loess Foothills	2	7	14.29%	0	2	0.00%	NA
Dissected Loess Uplands	1	20	5.00%	0	14	0.00%	NA
Eastern Puget Riverine Lowlands	0	68	0.00%	0	31	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Eastern Puget Uplands	0	176	0.00%	0	40	0.00%	NA
Fraser Lowland	0	113	0.00%	0	28	0.00%	NA
Grand Fir Mixed Forest	0	69	0.00%	0	19	0.00%	NA
High Northern Rockies	0	0	NA	0	0	NA	NA
High Olympics	0	37	0.00%	0	46	0.00%	NA
Inland Maritime Foothills and Valleys	8	24	33.33%	0	1	0.00%	NA
Loess Islands	1	33	3.03%	0	6	0.00%	NA
Low Olympics	0	50	0.00%	0	30	0.00%	NA
Lower Snake and Clearwater Canyons	0	14	0.00%	0	66	0.00%	NA
Maritime-Influenced Zone	1	2	50.00%	0	5	0.00%	NA
Mesic Forest Zone	0	14	0.00%	0	10	0.00%	NA
North Cascades Highland Forests	0	87	0.00%	0	36	0.00%	NA
North Cascades Lowland Forests	0	51	0.00%	0	28	0.00%	NA
North Cascades Subalpine/Alpine	0	117	0.00%	0	31	0.00%	NA
Northern Idaho Hills and Low Relief Mountains	1	22	4.55%	0	1	0.00%	NA
Oak/Conifer Foothills	0	42	0.00%	0	7	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Okanogan Drift Hills	0	14	0.00%	0	0	NA	NA
Okanogan Highland Dry Forest	0	24	0.00%	0	47	0.00%	NA
Okanogan Pine/Fir Hills	2	56	3.57%	0	51	0.00%	NA
Okanogan Valley	12	111	10.81%	0	11	0.00%	NA
Okanogan-Colville Xeric Valleys and Foothills	14	76	18.42%	1	56	1.79%	929.05%
Olympic Rainshadow	0	256	0.00%	0	66	0.00%	NA
Outwash	0	8	0.00%	0	0	NA	NA
Palouse Hills	6	105	5.71%	14	879	1.59%	259.12%
Pasayten/Sawtooth Highlands	0	50	0.00%	0	34	0.00%	NA
Pleistocene Lake Basins	6	191	3.14%	1	198	0.51%	515.69%
Portland/Vancouver Basin	0	100	0.00%	0	11	0.00%	NA
San Juan Islands	0	91	0.00%	0	129	0.00%	NA
Selkirk Mountains	0	33	0.00%	1	28	3.57%	-100.00%
Southern Puget Prairies	0	210	0.00%	0	187	0.00%	NA
Spokane Valley Outwash Plains	15	162	9.26%	1	40	2.50%	270.40%
Subalpine-Alpine Zone	0	3	0.00%	0	0	NA	NA
Valley Foothills	0	18	0.00%	0	1	0.00%	NA

Ecoregion	Number of Recent Observations (2011-2021)	Total Recent Observations of all Species (2011-2021)	Recent Relative Abundance (2011-2021)	Number of Historic Observations (1888-2010)	Total Historic Observations of all Species (1888-2010)	Historic Relative Abundance (1888-2010)	Change in Relative Abundance between Historic (1888-2010) and Recent (2011-2021)
Volcanics	0	55	0.00%	0	53	0.00%	NA
Wenatchee/Chelan Highlands	0	20	0.00%	0	22	0.00%	NA
Western Cascades Lowlands and Valleys	0	85	0.00%	0	65	0.00%	NA
Western Cascades Montane Highlands	0	55	0.00%	0	39	0.00%	NA
Western Okanogan Semiarid Foothills	0	10	0.00%	0	5	0.00%	NA
Western Selkirk Maritime Forest	0	13	0.00%	0	7	0.00%	NA
Willapa Hills	0	38	0.00%	0	14	0.00%	NA
Yakima Folds	0	133	0.00%	0	30	0.00%	NA
Yakima Plateau and Slopes	0	74	0.00%	0	27	0.00%	NA

Table B 10. Prioritization of conservation by level IV ecoregion based on mean recent predicted probability of presence. Mean predicted probability of presence for the recent (2011-2021) and historic (pre-2011) time periods is an average of the estimated probability that any of the focal species will be present in the ecoregion based on SDMs. The table is organized by mean recent predicted probability of presence from high to low.

Ecoregion	Priority	Mean Recent Predicted Probability of Presence (2011-2021)	Mean Historic Predicted Probability of Presence (pre-2011)	Change in Mean Predicted Probability of Presence
Spokane Valley Outwash Plains	High	35.76%	32.95%	2.81%
Inland Maritime Foothills and Valleys	High	33.20%	28.60%	4.60%
Maritime-Influenced Zone	High	32.84%	27.31%	5.54%
Northern Idaho Hills and Low Relief Mountains	High	31.97%	29.22%	2.75%
Palouse Hills	High	31.32%	28.16%	3.16%
Canyons and Dissected Highlands	High	31.06%	27.32%	3.74%
Mesic Forest Zone	High	31.00%	25.52%	5.48%
Okanogan Drift Hills	High	30.91%	28.82%	2.09%
Subalpine-Alpine Zone	High	30.14%	26.20%	3.94%
Western Selkirk Maritime Forest	High	29.25%	28.49%	0.76%
Okanogan Valley	High	28.87%	25.00%	3.86%
Okanogan Pine/Fir Hills	High	28.87%	27.16%	1.71%
Chiwaukum Hills and Lowlands	High	28.58%	21.32%	7.26%
Okanogan-Colville Xeric Valleys and Foothills	High	28.44%	22.33%	6.11%
Chelan Tephra Hills	High	28.17%	22.04%	6.13%
Western Okanogan Semiarid Foothills	High	28.13%	26.32%	1.81%
Deep Loess Foothills	High	27.30%	26.99%	0.31%
Selkirk Mountains	High	27.18%	28.35%	-1.18%
Yakima Plateau and Slopes	High	26.96%	19.34%	7.62%
Canyons and Dissected Uplands	Medium	25.37%	25.75%	-0.38%
Dissected Loess Uplands	Medium	24.55%	24.39%	0.15%
Oak/Conifer Foothills	Medium	24.44%	20.25%	4.19%

Ecoregion	Priority	Mean Recent Predicted Probability of Presence (2011-2021)	Mean Historic Predicted Probability of Presence (pre-2011)	Change in Mean Predicted Probability of Presence
Wenatchee/Chelan Highlands	Medium	22.78%	25.17%	-2.39%
Channeled Scablands	Medium	22.59%	15.95%	6.64%
Pasayten/Sawtooth Highlands	Medium	22.41%	27.69%	-5.28%
Grand Fir Mixed Forest	Medium	22.35%	24.85%	-2.49%
Okanogan Highland Dry Forest	Medium	22.22%	12.47%	9.75%
Loess Islands	Medium	22.07%	15.92%	6.15%
Portland/Vancouver Basin	Medium	21.83%	33.12%	-11.29%
Central Puget Lowland	Medium	21.64%	32.65%	-11.01%
Lower Snake and Clearwater Canyons	Medium	21.49%	24.22%	-2.73%
Southern Puget Prairies	Medium	21.43%	29.29%	-7.86%
Cowlitz/Newaukum Prairie Floodplains	Medium	19.95%	27.54%	-7.59%
Eastern Puget Riverine Lowlands	Medium	19.72%	36.05%	-16.33%
Cowlitz/Chehalis Foothills	Medium	19.56%	27.16%	-7.60%
Fraser Lowland	Medium	19.33%	39.40%	-20.06%
Valley Foothills	Medium	17.88%	25.17%	-7.30%
Cascade Crest Montane Forest	Medium	17.70%	27.50%	-9.79%
High Northern Rockies	Low	16.41%	27.53%	-11.12%
Eastern Puget Uplands	Low	16.36%	28.75%	-12.39%
Yakima Folds	Low	16.21%	13.74%	2.47%
Western Cascades Lowlands and Valleys	Low	16.07%	21.20%	-5.13%
Willapa Hills	Low	15.60%	23.28%	-7.68%
Pleistocene Lake Basins	Low	15.59%	19.48%	-3.89%
Olympic Rainshadow	Low	15.11%	29.09%	-13.98%
North Cascades Lowland Forests	Low	13.92%	22.63%	-8.71%
Western Cascades Montane Highlands	Low	13.83%	23.35%	-9.52%
North Cascades Highland Forests	Low	13.70%	24.20%	-10.50%

Ecoregion	Priority	Mean Recent Predicted Probability of Presence (2011-2021)	Mean Historic Predicted Probability of Presence (pre-2011)	Change in Mean Predicted Probability of Presence
Volcanics	Low	12.92%	20.25%	-7.33%
North Cascades Subalpine/Alpine	Low	12.07%	25.99%	-13.92%
Outwash	Low	11.29%	19.12%	-7.84%
Coastal Uplands	Low	10.88%	15.36%	-4.48%
San Juan Islands	Low	10.46%	31.98%	-21.52%
Coastal Lowlands	Low	10.06%	24.63%	-14.57%
Cascade Subalpine/Alpine	Low	10.06%	27.95%	-17.90%
Low Olympics	Low	9.58%	16.26%	-6.68%
High Olympics	Low	5.82%	24.50%	-18.68%

Table B 11. The combined mean predicted probability of species presence for all focal species during the historic (pre-2011) and recent (2011-2021) time periods and the change in number of species between the two time periods within each level IV ecoregion designated as medium or high priority for conservation. Predicted probability of species presence is based on SDMs. The table is sorted by mean recent predicted probability of species presence from high to low.

Ecoregion	Priority	Mean Historic Predicted Probability of Presence	Mean Recent Predicted Probability of Presence	Change in Mean Predicted Probability of Presence
Spokane Valley Outwash Plains	High	32.95%	35.76%	2.81%
Inland Maritime Foothills and Valleys	High	28.60%	33.20%	4.60%
Maritime-Influenced Zone	High	27.31%	32.84%	5.54%
Northern Idaho Hills and Low Relief Mountains	High	29.22%	31.97%	2.75%
Palouse Hills	High	28.16%	31.32%	3.16%
Canyons and Dissected Highlands	High	27.32%	31.06%	3.74%
Mesic Forest Zone	High	25.52%	31.00%	5.48%
Okanogan Drift Hills	High	28.82%	30.91%	2.09%
Subalpine-Alpine Zone	High	26.20%	30.14%	3.94%
Western Selkirk Maritime Forest	High	28.49%	29.25%	0.76%
Okanogan Valley	High	25.00%	28.87%	3.86%
Okanogan Pine/Fir Hills	High	27.16%	28.87%	1.71%
Chiwaukum Hills and Lowlands	High	21.32%	28.58%	7.26%
Okanogan-Colville Xeric Valleys and Foothills	High	22.33%	28.44%	6.11%
Chelan Tephra Hills	High	22.04%	28.17%	6.13%
Western Okanogan Semiarid Foothills	High	26.32%	28.13%	1.81%
Deep Loess Foothills	High	26.99%	27.30%	0.31%
Selkirk Mountains	High	28.35%	27.18%	-1.18%
Yakima Plateau and Slopes	High	19.34%	26.96%	7.62%
Canyons and Dissected Uplands	Medium	25.75%	25.37%	-0.38%
Dissected Loess Uplands	Medium	24.39%	24.55%	0.15%
Oak/Conifer Foothills	Medium	20.25%	24.44%	4.19%
Wenatchee/Chelan Highlands	Medium	25.17%	22.78%	-2.39%

Ecoregion	Priority	Mean Historic Predicted Probability of Presence	Mean Recent Predicted Probability of Presence	Change in Mean Predicted Probability of Presence
Channeled Scablands	Medium	15.95%	22.59%	6.64%
Pasayten/Sawtooth Highlands	Medium	27.69%	22.41%	-5.28%
Grand Fir Mixed Forest	Medium	24.85%	22.35%	-2.49%
Okanogan Highland Dry Forest	Medium	12.47%	22.22%	9.75%
Loess Islands	Medium	15.92%	22.07%	6.15%
Portland/Vancouver Basin	Medium	33.12%	21.83%	-11.29%
Central Puget Lowland	Medium	32.65%	21.64%	-11.01%
Lower Snake and Clearwater Canyons	Medium	24.22%	21.49%	-2.73%
Southern Puget Prairies	Medium	29.29%	21.43%	-7.86%
Cowlitz/Newaukum Prairie Floodplains	Medium	27.54%	19.95%	-7.59%
Eastern Puget Riverine Lowlands	Medium	36.05%	19.72%	-16.33%
Cowlitz/Chehalis Foothills	Medium	27.16%	19.56%	-7.60%
Fraser Lowland	Medium	39.40%	19.33%	-20.06%
Valley Foothills	Medium	25.17%	17.88%	-7.30%
Cascade Crest Montane Forest	Medium	27.50%	17.70%	-9.79%

Table B 12. The combined number of focal species during the historic (pre-2011) and recent (2011-2021) time periods and the change in number of species between the two time periods. Expected number of species is based on SDMs. The table is sorted by combined number of focal species in the recent time period (2011-2021) from high to low.

Ecoregion	Priority	Combined Historic Number of Focal Species (pre-2011)	Combined Recent Number of Focal Species (2011-2021)	Change in Number of Focal Species
Okanogan Drift Hills	High	7	8	1
Chelan Tephra Hills	High	7	8	1
Spokane Valley Outwash Plains	High	8	7	-1
Palouse Hills	High	8	7	-1
Northern Idaho Hills and Low Relief Mountains	High	7	7	0
Canyons and Dissected Highlands	High	7	7	0
Mesic Forest Zone	High	7	7	0
Okanogan Valley	High	7	7	0
Okanogan Pine/Fir Hills	High	7	7	0
Western Okanogan Semiarid Foothills	High	7	7	0
Inland Maritime Foothills and Valleys	High	6	7	1
Western Selkirk Maritime Forest	High	6	7	1
Okanogan-Colville Xeric Valleys and Foothills	High	6	7	1
Selkirk Mountains	High	6	7	1
Lower Snake and Clearwater Canyons	Medium	8	7	-1
Wenatchee/Chelan Highlands	Medium	6	7	1
Pasayten/Sawtooth Highlands	Medium	6	7	1
Yakima Plateau and Slopes	High	8	6	-2
Maritime-Influenced Zone	High	7	6	-1
Deep Loess Foothills	High	7	6	-1
Subalpine-Alpine Zone	High	6	6	0
Dissected Loess Uplands	Medium	8	6	-2
Oak/Conifer Foothills	Medium	8	6	-2

Ecoregion	Priority	Combined Historic Number of Focal Species (pre-2011)	Combined Recent Number of Focal Species (2011-2021)	Change in Number of Focal Species
Channeled Scablands	Medium	8	6	-2
Loess Islands	Medium	8	6	-2
Portland/Vancouver Basin	Medium	8	6	-2
Central Puget Lowland	Medium	8	6	-2
Eastern Puget Riverine Lowlands	Medium	8	6	-2
Southern Puget Prairies	Medium	7	6	-1
Cowlitz/Chehalis Foothills	Medium	7	6	-1
Fraser Lowland	Medium	7	6	-1
Canyons and Dissected Uplands	Medium	6	6	0
Cowlitz/Newaukum Prairie Floodplains	Medium	6	6	0
Chiwaukum Hills and Lowlands	High	7	5	-2
Grand Fir Mixed Forest	Medium	5	5	0
Okanogan Highland Dry Forest	Medium	5	5	0
Cascade Crest Montane Forest	Medium	5	4	-1
Valley Foothills	Medium	4	3	-1

Table B 13. Percent ownership within level IV ecoregions designated as medium or high priority for conservation. Within each ecoregion, red highlighting indicates the manager category covering the highest percentage of land in that ecoregion, orange indicates the second highest percentage, and yellow indicates the third highest percentage.

Ecoregion	Priority	Percent Other	Percent US Forest Service	Percent WA Dept of Natural Resources	Percent WA Dept of Fish and Wildlife	Percent US Bureau of Land Management	Percent County	Percent US Dept of Defense	Percent WA State Parks and Recreation Commission	Percent National Park Service	Percent US Fish and Wildlife Service	Percent City or Municipality	Percent Army Corps of Engineers	Percent US Bureau of Reclamation	Percent State University	Percent WA Dept of Corrections	Percent US Department of Energy	Percent WA Dept of Social and Health Services
Deep Loess Foothills	High	98.51	0.00	2.59	0.19	0.00	0.04	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Palouse Hills	High	97.35	0.00	2.99	0.00	0.00	0.05	0.00	0.02	0.00	0.00	0.02	0.00	0.00	0.44	0.00	0.00	0.00
Cowlitz/Chehalis Foothills	Medium	96.77	0.00	4.75	0.29	0.04	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cowlitz/ Newaukum Prairie Floodplains	Medium	95.55	0.00	4.14	0.16	0.00	0.03	0.00	0.43	0.00	0.01	0.03	0.00	0.00	0.00	0.05	0.00	0.00
Loess Islands	Medium	95.03	0.00	5.44	0.02	0.27	0.00	0.02	0.00	0.00	0.00	0.09	0.00	0.07	0.02	0.00	0.00	0.01
Fraser Lowland	Medium	94.88	0.06	2.89	0.93	0.01	0.47	0.00	0.09	0.00	0.00	0.59	0.00	0.00	0.11	0.00	0.00	0.00
Valley Foothills	Medium	93.87	2.76	4.80	0.19	0.00	0.00	0.34	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dissected Loess Uplands	Medium	93.78	0.17	5.07	2.51	0.07	0.01	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.00	0.00	0.00

Ecoregion	Priority	Percent Other	Percent US Forest Service	Percent WA Dept of Natural Resources	Percent WA Dept of Fish and Wildlife	Percent US Bureau of Land Management	Percent County	Percent US Dept of Defense	Percent WA State Parks and Recreation Commission	Percent National Park Service	Percent US Fish and Wildlife Service	Percent City or Municipality	Percent Army Corps of Engineers	Percent US Bureau of Reclamation	Percent State University	Percent WA Dept of Corrections	Percent US Department of Energy	Percent WA Dept of Social and Health Services
Eastern Puget Riverine Lowlands	Medium	93.56	0.49	3.31	1.62	0.01	1.36	0.00	0.16	0.00	0.03	0.67	0.01	0.00	0.00	0.07	0.00	0.05
Spokane Valley Outwash Plains	High	92.18	0.00	5.05	0.05	0.00	0.94	0.10	2.17	0.00	0.00	1.86	0.00	0.00	0.09	0.00	0.00	0.00
Portland/ Vancouver Basin	Medium	90.51	0.00	3.36	1.57	0.01	1.61	0.04	0.25	0.04	3.43	0.62	0.00	0.00	0.00	0.00	0.00	0.00
Northern Idaho Hills and Low Relief Mountains	High	87.90	0.00	5.04	0.00	0.00	9.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central Puget Lowland	Medium	87.64	0.32	9.05	0.47	0.00	0.64	0.82	0.43	0.00	0.04	1.60	0.00	0.00	0.19	0.16	0.00	0.00
Western Okanogan Semiarid Foothills	High	86.77	7.66	5.02	0.94	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lower Snake and Clearwater Canyons	Medium	83.78	3.20	7.64	9.62	0.44	0.01	0.00	0.00	0.00	0.00	0.00	2.05	0.00	0.27	0.00	0.00	0.00
Okanogan Drift Hills	High	82.15	0.00	15.97	1.89	0.53	0.00	0.23	0.12	0.00	0.00	0.00	0.03	0.10	0.00	0.00	0.00	0.00

Ecoregion	Priority	Percent Other	Percent US Forest Service	Percent WA Dept of Natural Resources	Percent WA Dept of Fish and Wildlife	Percent US Bureau of Land Management	Percent County	Percent US Dept of Defense	Percent WA State Parks and Recreation Commission	Percent National Park Service	Percent US Fish and Wildlife Service	Percent City or Municipality	Percent Army Corps of Engineers	Percent US Bureau of Reclamation	Percent State University	Percent WA Dept of Corrections	Percent US Department of Energy	Percent WA Dept of Social and Health Services
Okanogan-Colville Xeric Valleys and Foothills	High	80.56	6.96	7.96	0.48	1.13	0.10	0.00	0.02	2.18	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channeled Scablands	Medium	80.02	0.30	8.52	2.42	6.33	0.16	0.18	0.54	0.93	0.85	0.23	0.08	1.97	0.02	0.01	0.00	0.04
Southern Puget Prairies	Medium	79.98	0.00	4.19	0.51	0.00	0.43	15.23	0.34	0.00	0.56	0.40	0.00	0.00	0.00	0.00	0.00	0.06
Okanogan Valley	High	77.34	3.28	8.62	7.09	4.57	0.15	0.04	0.17	0.01	0.17	0.01	0.00	0.15	0.00	0.00	0.00	0.00
Oak/Conifer Foothills	Medium	76.46	5.78	16.27	0.89	1.47	0.00	0.00	0.25	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maritime-Influenced Zone	High	76.29	16.84	7.28	0.00	0.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Maritime Foothills and Valleys	High	66.78	25.83	5.67	0.00	0.02	1.75	0.00	0.07	0.00	0.13	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Canyons and Dissected Uplands	Medium	63.44	0.42	4.69	20.02	15.34	0.00	0.00	0.29	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Western Selkirk Maritime Forest	High	61.16	5.77	23.87	0.00	4.20	0.16	0.00	6.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Ecoregion	Priority	Percent Other	Percent US Forest Service	Percent WA Dept of Natural Resources	Percent WA Dept of Fish and Wildlife	Percent US Bureau of Land Management	Percent County	Percent US Dept of Defense	Percent WA State Parks and Recreation Commission	Percent National Park Service	Percent US Fish and Wildlife Service	Percent City or Municipality	Percent Army Corps of Engineers	Percent US Bureau of Reclamation	Percent State University	Percent WA Dept of Corrections	Percent US Department of Energy	Percent WA Dept of Social and Health Services
Yakima Plateau and Slopes	High	55.16	15.89	20.86	8.12	0.46	0.00	0.00	0.09	0.00	0.54	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Subalpine-Alpine Zone	High	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pasayten/Sawtooth Highlands	Medium	0.22	90.45	9.12	0.01	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wenatchee/Chelan Highlands	Medium	8.72	83.88	0.24	0.08	0.00	0.00	0.00	0.01	6.98	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cascade Crest Montane Forest	Medium	21.24	79.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Canyons and Dissected Highlands	High	13.30	78.78	2.01	6.18	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mesic Forest Zone	High	19.18	78.67	1.88	0.40	0.13	0.00	0.00	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00
Chelan Tephra Hills	High	18.74	75.26	3.97	1.11	1.30	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selkirk Mountains	High	22.19	70.25	5.85	0.10	0.21	0.02	0.00	0.00	0.00	1.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand Fir Mixed Forest	Medium	35.84	53.10	10.01	1.24	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Ecoregion	Priority	Percent Other	Percent US Forest Service	Percent WA Dept of Natural Resources	Percent WA Dept of Fish and Wildlife	Percent US Bureau of Land Management	Percent County	Percent US Dept of Defense	Percent WA State Parks and Recreation Commission	Percent National Park Service	Percent US Fish and Wildlife Service	Percent City or Municipality	Percent Army Corps of Engineers	Percent US Bureau of Reclamation	Percent State University	Percent WA Dept of Corrections	Percent US Department of Energy	Percent WA Dept of Social and Health Services
Chiwaukum Hills and Lowlands	High	34.08	52.39	13.07	0.33	0.23	0.00	0.00	0.31	0.00	0.03	0.21	0.00	0.00	0.00	0.00	0.00	0.00
Okanogan Pine/Fir Hills	High	23.60	50.00	19.60	2.82	3.49	0.00	0.00	0.03	0.00	0.62	0.00	0.00	0.07	0.00	0.00	0.00	0.00
Okanogan Highland Dry Forest	Medium	47.80	49.33	2.78	0.08	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Average		64.01	25.18	6.94	1.90	1.10	0.46	0.45	0.37	0.27	0.26	0.19	0.07	0.06	0.03	0.01	0.00	0.00

Table B 14. Percent ownership within low priority level IV ecoregions that are designated as a priority for the conservation of a few species based on occurrence records. Within each ecoregion, red highlighting indicates the manager category covering the highest percentage of land in that ecoregion, orange indicates the second highest percentage, and yellow indicates the third highest percentage.

Ecoregion	Other	US Forest Service	WA Dept of Natural Resources	WA Dept of Fish and Wildlife	US Bureau of Land Management	County	US Dept of Defense	WA State Parks and Recreation Commission	National Park Service	US Fish and Wildlife Service	City or Municipality	Army Corps of Engineers	US Bureau of Reclamation	State University	WA Dept of Corrections	US Department of Energy	WA Dept of Social and Health Services
Eastern Puget Uplands	79.10	0.03	15.26	0.21	0.01	2.62	0.00	0.76	0.00	0.00	3.23	0.00	0.00	0.00	0.00	0.00	0.13
Yakima Folds	67.05	0.14	8.64	8.26	2.99	0.04	12.13	0.37	0.00	1.82	0.00	0.00	0.82	0.02	0.00	0.10	0.00
Olympic Rainshadow	66.46	9.94	14.34	0.26	0.01	0.19	2.35	2.13	5.00	0.17	0.42	0.00	0.00	0.01	0.00	0.00	0.00
Western Cascades Lowlands and Valleys	58.07	20.60	18.04	0.46	0.05	0.20	0.14	0.42	0.44	0.07	2.58	0.02	0.00	0.23	0.00	0.00	0.00
Western Cascades Montane Highlands	17.00	67.88	5.32	0.10	0.00	0.00	0.00	0.00	7.55	0.00	2.30	0.00	0.00	0.00	0.00	0.00	0.00

Ecoregion	Other	US Forest Service	WA Dept of Natural Resources	WA Dept of Fish and Wildlife	US Bureau of Land Management	County	US Dept of Defense	WA State Parks and Recreation Commission	National Park Service	US Fish and Wildlife Service	City or Municipality	Army Corps of Engineers	US Bureau of Reclamation	State University	WA Dept of Corrections	US Department of Energy	WA Dept of Social and Health Services
Cascade Subalpine/Alpine	10.38	45.55	0.00	0.00	0.00	0.00	0.00	0.00	44.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
North Cascades Subalpine/Alpine	0.33	82.26	0.68	0.00	0.00	0.00	0.00	0.00	16.73	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
High Olympics	0.06	14.23	0.00	0.00	0.00	0.00	0.00	0.00	85.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table B 15. Percent cover by land cover types within level IV ecoregions designated as medium or high priority for conservation. Within each ecoregion, red highlighting indicates the land cover type covering the highest percentage of land in that ecoregion, orange indicates the second highest percentage, and yellow indicates the third highest percentage.

Ecoregion	Priority	Percent Evergreen Forest	Percent Shrub / Scrub	Percent Herbaceous	Percent Cultivated Crops	Percent Hay / Pasture	Percent Developed, Open Space	Percent Developed, Low Intensity	Percent Developed, Medium Intensity	Percent Woody Wetlands	Percent Mixed Forest	Percent Open Water	Percent Deciduous Forest	Percent Emergent Herbaceous Wetlands	Percent Developed, High Intensity	Percent Barren Land
Canyons and Dissected Highlands	High	59.26	16.45	21.7	0.4	0.1	1.82	0.22	0.02	0.01	0.01	0	0	0.01	0	0
Canyons and Dissected Uplands	Medium	13.21	22.19	61.26	0.86	0.17	0.3	0.18	0.06	0.03	0	1.7	0	0.03	0	0
Cascade Crest Montane Forest	Medium	77.25	5.83	10.74	0	0	1.17	0.91	0.36	2.22	0	0.39	0.05	0.3	0.09	0.69
Central Puget Lowland	Medium	33.63	5.34	2.03	0.03	2	9.11	13.19	12.03	3.51	7.71	1.35	3.76	1.09	4.71	0.5
Channeled Scablands	Medium	3.49	33.87	39.67	11.85	0.81	1.46	1.4	0.92	0.6	0	3.7	0.01	1.98	0.2	0.07
Chelan Tephra Hills	High	27.34	34.84	26.75	0.25	0.13	1.5	1	1.01	0.28	0.03	6.24	0.01	0.13	0.48	0
Chiwaukum Hills and Lowlands	High	59.78	18.04	9.44	1.19	1.94	3.34	2.27	0.66	1.29	0.17	1.24	0.19	0.2	0.12	0.14
Cowlitz/Chehalis Foothills	Medium	45.56	7.4	3.92	0.03	8.03	4.74	3.7	2.48	4.27	7.19	1.94	5.94	2.82	1.43	0.53
Cowlitz/Newaukum Prairie Floodplains	Medium	23.34	5.34	1.92	0.45	28.72	5.44	3.86	1.97	12.46	6.62	0.96	5.3	2.7	0.88	0.04
Deep Loess Foothills	High	6.82	5.11	8.66	69.67	4.92	3.03	0.87	0.2	0.11	0.06	0	0	0.51	0.04	0
Dissected Loess Uplands	Medium	1.66	7.48	45.22	38.8	1.84	1.96	0.76	0.39	0.08	0.01	1.56	0.02	0.18	0.04	0

Ecoregion	Priority	Percent Evergreen Forest	Percent Shrub / Scrub	Percent Herbaceous	Percent Cultivated Crops	Percent Hay / Pasture	Percent Developed, Open Space	Percent Developed, Low Intensity	Percent Developed, Medium Intensity	Percent Woody Wetlands	Percent Mixed Forest	Percent Open Water	Percent Deciduous Forest	Percent Emergent Herbaceous Wetlands	Percent Developed, High Intensity	Percent Barren Land
Eastern Puget Riverine Lowlands	Medium	4.55	1.83	0.95	15.69	18.26	7.39	10.94	9.09	4.82	9.04	2.56	3.53	5.59	5.31	0.47
Fraser Lowland	Medium	2.8	1.25	0.51	17.61	28.01	6.23	9.3	5.35	6.34	5.74	0.93	7.4	5.98	2.28	0.25
Grand Fir Mixed Forest	Medium	72.84	16.02	4.84	0.06	0.64	2.24	1.08	0.35	0.99	0.05	0.17	0.21	0.21	0.13	0.18
Inland Maritime Foothills and Valleys	High	67.6	9.59	5.28	0.11	3.22	1.37	1.02	0.3	3.02	0.05	3.69	0.06	4.58	0.06	0.06
Loess Islands	Medium	0.11	15.86	9.17	70.84	0.86	1.57	0.81	0.53	0.03	0	0.02	0	0.13	0.06	0
Lower Snake and Clearwater Canyons	Medium	3.5	22.24	61.28	6.44	0.2	0.83	0.63	0.35	0.04	0.01	4.21	0.02	0.19	0.06	0
Maritime-Influenced Zone	High	49.48	20.91	24.51	2.13	0.33	2.44	0.14	0.01	0.01	0	0	0	0.03	0	0
Mesic Forest Zone	High	75.55	14.29	6.88	0.42	0.22	2.38	0.22	0.02	0	0	0	0	0	0	0
Northern Idaho Hills and Low Relief Mountains	High	46.47	19.68	9.26	14.2	0.86	3.07	4.53	1.11	0.14	0.04	0.04	0.04	0.45	0.07	0.03
Oak/Conifer Foothills	Medium	38.99	26.54	19.96	3.92	0.48	2.97	1.77	0.34	0.43	1.65	1.34	1.39	0.14	0.08	0.01
Okanogan Drift Hills	High	0.33	48.70	11.80	34.12	0.46	1.56	0.78	0.42	0.19	0.00	1.12	0.00	0.46	0.04	0.01
Okanogan Highland Dry Forest	Medium	65.72	20.05	12.92	0.00	0.01	0.37	0.12	0.02	0.55	0.01	0.04	0.06	0.10	0.00	0.00
Okanogan Pine/Fir Hills	High	40.45	25.71	26.78	0.17	0.33	2.71	1.33	0.33	0.72	0.10	0.62	0.13	0.58	0.03	0.02
Okanogan Valley	High	4.03	38.36	39.67	5.12	3.03	1.84	1.82	0.84	0.57	0.00	3.29	0.02	1.22	0.16	0.04

Ecoregion	Priority	Percent Evergreen Forest	Percent Shrub / Scrub	Percent Herbaceous	Percent Cultivated Crops	Percent Hay / Pasture	Percent Developed, Open Space	Percent Developed, Low Intensity	Percent Developed, Medium Intensity	Percent Woody Wetlands	Percent Mixed Forest	Percent Open Water	Percent Deciduous Forest	Percent Emergent Herbaceous Wetlands	Percent Developed, High Intensity	Percent Barren Land
Okanogan-Colville Xeric Valleys and Foothills	High	58.65	22.86	8.22	1.81	0.91	0.89	0.80	0.26	1.05	0.04	3.10	0.17	1.17	0.04	0.03
Palouse Hills	High	1.49	2.56	1.77	87	2.91	1.96	1.36	0.58	0.04	0	0.01	0.01	0.2	0.08	0.01
Pasayten/ Sawtooth Highlands	Medium	39.5	37.27	18.52	0.01	0.01	0.91	0.26	0.13	0.71	0.11	0.07	0.05	0.07	0.05	2.34
Portland/ Vancouver Basin	Medium	3.84	1.21	0.48	1.58	26.72	11.49	18.14	16.35	3.32	2.27	1.42	3.22	4.55	5.15	0.25
Selkirk Mountains	High	87.36	7.48	2.53	0	0.08	0.5	0.17	0.05	0.43	0.18	0.92	0.08	0.19	0.01	0.03
Southern Puget Prairies	Medium	24.02	4.4	4.5	0.25	14.43	8.93	12.26	8.18	5.44	8.34	1.32	2.18	2.6	2.82	0.34
Spokane Valley Outwash Plains	High	24.6	21.97	7.11	13.47	0.78	5.89	11.09	9.25	0.55	0	1.27	0.01	1.92	2.09	0.01
Subalpine-Alpine Zone	High	82.53	10.38	2.4	0	0	4.38	0.28	0.03	0	0	0	0	0	0	0
Valley Foothills	Medium	20.95	4.38	1.23	0.03	27.68	13.25	7.29	0.82	2.63	8.7	0.47	12.14	0.31	0.08	0.03
Wenatchee/ Chelan Highlands	Medium	45.44	26.49	19.35	0.01	0.07	0.59	0.4	0.11	1.2	0.29	3.99	0.24	0.08	0.04	1.7
Western Okanogan Semiarid Foothills	High	29.28	34.75	33.05	0.07	0.13	0.47	0.28	0.07	0.95	0	0.41	0	0.54	0	0
Western Selkirk Maritime Forest	High	76.71	14.65	6.69	0.12	0.09	0.49	0.19	0.02	0.13	0.22	0.01	0.13	0.41	0	0.15
Yakima Plateau and Slopes	High	55.35	25.39	11.79	0.02	0.6	2.77	1.63	0.36	0.67	0.16	0.3	0.1	0.66	0.11	0.08

Table B 16. Medium and high priority ecoregions in which the land cover is more than 10% forest. In the 'Percent Forest' column highlighting indicates if forest is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. Additional columns include land cover percentage by type of forest. In the 'Threats' columns the letters indicate the following threats: A&D - agriculture and development, G - grazing, F - fire, P - pesticides, CC - climate change. The table is sorted by percent forest from high to low.

Ecoregion	Priority	Percent Evergreen Forest	Percent Mixed Forest	Percent Deciduous Forest	Percent Forest	Threat Score	Threats (High)	Threats (Medium)
Selkirk Mountains	High	87.36	0.18	0.08	87.62	Medium	CC	G
Subalpine-Alpine Zone	High	82.53	0	0	82.53	Medium		F, CC
Cascade Crest Montane Forest	Medium	77.25	0	0.05	77.3	Medium	CC	P
Western Selkirk Maritime Forest	High	76.71	0.22	0.13	77.06	Medium	CC	
Mesic Forest Zone	High	75.55	0	0	75.55	Medium		F, CC
Grand Fir Mixed Forest	Medium	72.84	0.05	0.21	73.09	High	F, P, CC	G
Inland Maritime Foothills and Valleys	High	67.6	0.05	0.06	67.71	Medium		A&D, CC
Okanogan Highland Dry Forest	Medium	65.71	0.01	0.05	65.77	High	A&D, G	CC
Chiwaukum Hills and Lowlands	High	59.78	0.17	0.19	60.13	High	F, CC	A&D, G
Canyons and Dissected Highlands	High	59.26	0.01	0	59.27	Medium		A&D, G, F, CC
Okanogan-Colville Xeric Valleys and Foothills	High	58.64	0.04	0.17	58.85	Medium		CC
Cowlitz/Chehalis Foothills	Medium	45.56	7.19	5.94	58.69	Medium		A&D, CC
Yakima Plateau and Slopes	High	55.35	0.16	0.1	55.61	High	P, CC	F
Maritime-Influenced Zone	High	49.48	0	0	49.49	Medium		A&D, CC
Northern Idaho Hills and Low Relief Mountains	High	46.47	0.04	0.04	46.55	Medium		A&D, CC
Wenatchee/Chelan Highlands	Medium	45.44	0.29	0.24	45.97	Medium	F	CC
Central Puget Lowland	Medium	33.63	7.71	3.76	45.1	Medium		A&D, CC

Ecoregion	Priority	Percent Evergreen Forest	Percent Mixed Forest	Percent Deciduous Forest	Percent Forest	Threat Score	Threats (High)	Threats (Medium)
Oak/Conifer Foothills	Medium	38.99	1.65	1.39	42.03	Medium		A&D, CC
Valley Foothills	Medium	20.95	8.7	12.14	41.8	Medium	A&D	CC
Okanogan Pine/Fir Hills	High	40.44	0.10	0.13	40.67	High	G, CC	P
Pasayten/Sawtooth Highlands	Medium	39.5	0.11	0.05	39.66	Medium		G, P, CC
Cowlitz/Newaukum Prairie Floodplains	Medium	23.34	6.62	5.3	35.26	Low		A&D, CC
Southern Puget Prairies	Medium	24.02	8.34	2.18	34.54	Medium		A&D, CC
Western Okanogan Semiarid Foothills	High	29.28	0	0	29.29	Medium		CC
Chelan Tephra Hills	High	27.34	0.03	0.01	27.38	Medium	G	CC
Spokane Valley Outwash Plains	High	24.6	0	0.01	24.61	Medium		A&D, CC
Eastern Puget Riverine Lowlands	Medium	4.55	9.04	3.53	17.12	Low		A&D, CC
Fraser Lowland	Medium	2.8	5.74	7.4	15.94	Low		CC
Canyons and Dissected Uplands	Medium	13.21	0	0	13.21	Low		CC

Table B 17. Ecoregions not designated as medium or high priority, with a high number of occurrence records, in which the land cover is more than 10% forest. In the 'Percent Forest' column highlighting indicates if forest is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. Additional columns include land cover percentage by type of forest. In the 'Threats' columns the letters indicate the following threats: A&D - agriculture and development, P - pesticides, CC - climate change. The table is sorted by percent forest from high to low.

Ecoregion	Percent Evergreen Forest	Percent Mixed Forest	Percent Deciduous Forest	Percent Forest	Threat Score	Threats (High)	Threats (Medium)
Western Cascades Montane Highlands	84.44	0.12	0.15	84.71	0.35		CC
Western Cascades Lowlands and Valleys	68.67	6.71	2.88	78.27	0.28		A&D, CC
High Olympics	62.65	0.05	0.07	62.77	0.31	CC	
Olympic Rainshadow	48.82	9.6	3.61	62.03	0.32		A&D, CC
Eastern Puget Uplands	27	25.25	5.1	57.36	0.38	A&D	CC
Cascade Subalpine/Alpine	42.19	0.03	0.06	42.29	0.52	CC	P
North Cascades Subalpine/Alpine	40.76	0.12	0.15	41.03	0.42	CC	

Table B 18. Medium and high priority ecoregions in which the land cover is more than 10% shrub/scrub. In the 'Percent Shrub/Scrub' column highlighting indicates if shrub/scrub is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. In the 'Threats' columns the letters indicate the following threats: A&D - agriculture and development, G - grazing, F - fire, P - pesticides, CC - climate change. The table is sorted by percent shrub/scrub from high to low.

Ecoregion	Priority	Percent Shrub/Scrub	Threat Score	Threats (High)	Threats (Medium)
Okanogan Drift Hills	H	48.69	Medium	A&D, CC	
Okanogan Valley	H	38.35	Medium	CC	G
Pasayten/Sawtooth Highlands	M	37.27	Medium		G, P, CC
Chelan Tephra Hills	H	34.84	Medium	G	CC
Western Okanogan Semiarid Foothills	H	34.75	Medium		CC
Channeled Scablands	M	33.87	Medium	A&D	P, CC
Oak/Conifer Foothills	M	26.54	Medium		A&D, CC
Wenatchee/Chelan Highlands	M	26.49	Medium	F	CC
Okanogan Pine/Fir Hills	H	25.70	High	G, CC	P
Yakima Plateau and Slopes	H	25.39	High	P, CC	F
Okanogan-Colville Xeric Valleys and Foothills	H	22.86	Medium		CC
Lower Snake and Clearwater Canyons	M	22.24	Low		CC
Canyons and Dissected Uplands	M	22.19	Low		CC
Spokane Valley Outwash Plains	H	21.97	Medium		A&D, CC
Maritime-Influenced Zone	H	20.91	Medium		A&D, CC
Okanogan Highland Dry Forest	M	20.05	High	A&D, G	CC
Northern Idaho Hills and Low Relief Mountains	H	19.68	Medium		A&D, CC
Chiwaukum Hills and Lowlands	H	18.04	High	F, CC	A&D, G
Canyons and Dissected Highlands	H	16.45	Medium		A&D, G, F, CC

Ecoregion	Priority	Percent Shrub/Scrub	Threat Score	Threats (High)	Threats (Medium)
Grand Fir Mixed Forest	M	16.02	High	F, P, CC	G
Loess Islands	M	15.86	Medium		P, CC
Western Selkirk Maritime Forest	H	14.65	Medium	CC	
Mesic Forest Zone	H	14.29	Medium		F, CC
Subalpine-Alpine Zone	H	10.38	Medium		F, CC

Table B 19. Ecoregions not designated as medium or high priority, with a high number of occurrence records, in which the land cover is more than 10% shrub/scrub. In the ‘Percent Shrub/Scrub’ column highlighting indicates if shrub/scrub is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. In the ‘Threats’ columns the letters indicate the following threats: A&D - agriculture and development, P - pesticides, CC - climate change. The table is sorted by percent shrub/scrub from high to low.

Ecoregion	Percent Shrub/Scrub	Threat Score	Threats (High)	Threats (Medium)
Yakima Folds	29.61	0.61	P	A&D, CC
Cascade Subalpine/Alpine	17.19	0.52	CC	P
North Cascades Subalpine/Alpine	16.42	0.42	CC	

Table B 20. Medium and high priority ecoregions in which the land cover is more than 10% herbaceous. In the ‘Percent Herbaceous’ column highlighting indicates if herbaceous is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. In the ‘Threats’ columns the letters indicate the following threats: A&D - agriculture and development, G - grazing, F - fire, P - pesticides, CC - climate change. The table is sorted by percent herbaceous from high to low.

Ecoregion	Priority	Percent Herbaceous	Threat Score	Threats (High)	Threats (Medium)
Lower Snake and Clearwater Canyons	M	61.28	Low		CC
Canyons and Dissected Uplands	M	61.26	Medium		A&D, G, F, CC
Dissected Loess Uplands	M	45.22	Low		CC
Channeled Scablands	M	39.67	Medium	A&D	P, CC
Okanogan Valley	H	39.67	Medium	CC	G
Western Okanogan Semiarid Foothills	H	33.05	Medium		CC
Okanogan Pine/Fir Hills	H	26.77	High	G, CC	P
Chelan Tephra Hills	H	26.75	Medium	G	CC
Maritime-Influenced Zone	H	24.51	Medium		A&D, CC
Canyons and Dissected Highlands	H	21.7	Medium		A&D, G, F, CC
Oak/Conifer Foothills	M	19.96	Medium		A&D, CC
Wenatchee/Chelan Highlands	M	19.35	Medium	F	CC
Pasayten/Sawtooth Highlands	M	18.52	Medium		G, P, CC
Okanogan Highland Dry Forest	M	12.92	High	G	CC
Okanogan Drift Hills	H	11.80	Medium	A&D, CC	
Yakima Plateau and Slopes	H	11.79	High	P, CC	F
Cascade Crest Montane Forest	M	10.74	Medium	CC	P

Table B 21. Ecoregions not designated as medium or high priority, with a high number of occurrence records, in which the land cover is more than 10% herbaceous. In the ‘Percent Herbaceous’ column highlighting indicates if herbaceous is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. In the ‘Threats’ columns the letters indicate the following threats: A&D - agriculture and development, P - pesticides, CC - climate change. The table is sorted by percent herbaceous from high to low.

Ecoregion	Percent Herbaceous	Threat Score	Threats (High)	Threats (Medium)
Yakima Folds	45.79	0.61	P	A&D, CC
North Cascades Subalpine/Alpine	11.88	0.42	CC	

Table B 22. Medium and high priority ecoregions in which the land cover is more than 10% cultivated crops and hay/pasture. In the 'Percent Cultivated Crops and Hay/Pasture' column highlighting indicates if cultivated crops and hay/pasture is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. Additional columns include land cover percentage by cultivated crops or hay/pasture. In the 'Threats' columns the letters indicate the following threats: A&D - agriculture and development, P - pesticides, CC - climate change. The table is sorted by percent hay/pasture from high to low.

Ecoregion	Priority	Percent Cultivated Crops	Percent Hay/Pasture	Percent Cultivated Crops and Hay/Pasture	Threat Score	Threats (High)	Threats (Medium)
Palouse Hills	H	87	2.91	89.92	Medium		P, CC
Deep Loess Foothills	H	69.67	4.92	74.59	Low		CC
Loess Islands	M	70.84	0.86	71.7	Medium		P, CC
Fraser Lowland	M	17.61	28.01	45.62	Low		CC
Dissected Loess Uplands	M	38.8	1.84	40.63	Low		CC
Okanogan Drift Hills	H	34.12	0.46	34.57	Medium	A&D, CC	
Eastern Puget Riverine Lowlands	M	15.69	18.26	33.94	Low		A&D, CC
Cowlitz/Newaukum Prairie Floodplains	M	0.45	28.72	29.17	Low		A&D, CC
Portland/Vancouver Basin	M	1.58	26.72	28.3	Medium	A&D	CC
Valley Foothills	M	0.03	27.68	27.71	Medium	A&D	CC
Northern Idaho Hills and Low Relief Mountains	H	14.2	0.86	15.06	Medium		A&D, CC
Southern Puget Prairies	M	0.25	14.43	14.68	Medium		A&D, CC
Spokane Valley Outwash Plains	H	13.47	0.78	14.25	Medium		A&D, CC
Channeled Scablands	M	11.85	0.81	12.65	Medium	A&D	P, CC

Table B 23. Ecoregions not designated as medium or high priority, with a high number of occurrence records, in which the land cover is more than 10% cultivated crops and hay/pasture. In the ‘Percent Cultivated Crops and Hay/Pasture’ column highlighting indicates if cultivated crops and hay/pasture is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. Additional columns include land cover percentage by cultivated crops or hay/pasture. In the ‘Threats’ columns the letters indicate the following threats: A&D - agriculture and development, P - pesticides, CC - climate change.

Ecoregion	Percent Cultivated Crops	Percent Hay/ Pasture	Percent Cultivated Crops and Hay/Pasture	Threat Score	Threats (High)	Threats (Medium)
Yakima Folds	19.08	1.26	20.34	0.61	P	A&D, CC

Table B 24. Medium and high priority ecoregions in which the land cover is more than 10% developed. In the 'Percent Developed' column highlighting indicates if development is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. Additional columns include land cover percentage by type of development. In the 'Threats' columns the letters indicate the following threats: A&D - agriculture and development, CC - climate change. The table is sorted by percent development from high to low.

Ecoregion	Priority	Percent Developed, Open Space	Percent Developed, Low Intensity	Percent Developed, Medium Intensity	Percent Developed, High Intensity	Percent Developed	Threat Score	Threats (High)	Threats (Medium)
Portland/Vancouver Basin	Medium	11.49	18.14	16.35	5.15	51.14	Medium	A&D	CC
Central Puget Lowland	Medium	9.11	13.19	12.03	4.71	39.04	Medium		A&D, CC
Eastern Puget Riverine Lowlands	Medium	7.39	10.94	9.09	5.31	32.73	Low		A&D, CC
Southern Puget Prairies	Medium	8.93	12.26	8.18	2.82	32.18	Medium		A&D, CC
Spokane Valley Outwash Plains	High	5.89	11.09	9.25	2.09	28.32	Medium		A&D, CC
Fraser Lowland	Medium	6.23	9.3	5.35	2.28	23.17	Low		CC
Valley Foothills	Medium	13.25	7.29	0.82	0.08	21.45	Medium	A&D	CC
Cowlitz/Chehalis Foothills	Medium	4.74	3.7	2.48	1.43	12.35	Medium		A&D, CC
Cowlitz/Newaukum Prairie Floodplains	Medium	5.44	3.86	1.97	0.88	12.15	Low		A&D, CC

Table B 25. Ecoregions not designated as medium or high priority, with a high number of occurrence records, in which the land cover is more than 10% developed. In the ‘Percent Developed’ column highlighting indicates if development is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. Additional columns include land cover percentage by type of development. In the ‘Threats’ columns the letters indicate the following threats: A&D - agriculture and development, CC - climate change. The table is sorted by percent development from high to low.

Ecoregion	Percent Developed, Open Space	Percent Developed, Low Intensity	Percent Developed, Medium Intensity	Percent Developed, High Intensity	Percent Developed Total	Threat Score	Threats (High)	Threats (Medium)
Eastern Puget Uplands	10.32	9.95	4.12	0.69	25.08	0.38	A&D	CC
Olympic Rainshadow	5.59	7.07	3.68	1.01	17.36	0.32		A&D, CC

Table B 26. Medium and high priority ecoregions in which the land cover is more than 10% woody wetland. In the 'Percent Woody Wetland' column highlighting indicates if woody wetland is the first (red), second (orange), or third (yellow) most prevalent land cover in that ecoregion. In the 'Threats' columns the letters indicate the following threats: A&D - agriculture and development, CC - climate change.

Ecoregion	Priority	Percent Woody Wetlands	Threat Score	Threats (High)	Threats (Medium)
Cowlitz/Newaukum Prairie Floodplains	Medium	12.46	Low		A&D, CC

Appendix C: Native Plant Lists

Table C 1. Plant genera associated with focal species. Associations are based on the top ten genera connected with occurrence records from the Pacific Northwest Bumble Bee Atlas. Note that these floral associations do not necessarily represent a species' preference for these plants over other flowering plants, but rather may represent the abundance of these flowers in the landscape. There was insufficient data to include plants associated with *B. frigidus*, *B. suckleyi*, *B. kirbiellus*, or *B. pensylvanicus*.

Plant Genus	Associated Focal Species	Multi-species Appeal	Important Food Plant
Agastache	*B. fervidus, B. vagans*	✔	✔
Anaphalis	*B. occidentalis*		
*Carduus**	*B. fervidus*		
Castilleja	*B. fervidus*		
*Centaurea**	*B. occidentalis, B. vagans*		✔
Chamaenerion	*B. occidentalis, B. vagans*	✔	✔
*Cirsium**	*B. fervidus, B. morrisoni, B. occidentalis, B. vagans*	✔	✔
Delphinium	*B. fervidus*		
*Dipsacus**	*B. morrisoni, B. vagans*	✔	
Helianthus	*B. vagans*		
Hypericum	*B. occidentalis, B. vagans*	✔	
Lavandula	*B. morrisoni, B. occidentalis, B. vagans*		✔
Lupinus	*B. occidentalis*	✔	✔
Lythrum	*B. morrisoni*		
Melilotus	*B. morrisoni*		
Monarda	*B. morrisoni*		
Nepeta	*B. morrisoni*		
Origanum	*B. occidentalis*		
Penstemon	*B. fervidus*	✔	✔
Prunella	*B. fervidus*		
Securigera	*B. morrisoni*		
Solidago	*B. occidentalis*		

Plant Genus	Associated Focal Species	Multi-species Appeal	Important Food Plant
Spirea	*B. occidentalis*		
Symphoricarpos	*B. vagans*	✔	✔
Thermopsis	*B. fervidus*		
Trifolium	*B. fervidus, B. vagans*	✔	✔
Vivia	*B. fervidus*		
Zauschneria	*B. morrisoni*		
Zinnia	*B. morrisoni*		

* An asterisk following genus name indicates genera containing all or some non-native, invasive plants. While bumble bees often obtain pollen and nectar from non-native plants, native plants should be prioritized when restoring, maintaining, and improving habitat for pollinators.

Table C 2. Plant genera associated with bumble bee species of conservation concern along with approximate bloom time. Every genus listed includes native species. We recommend planting native species within these genera when completing restoration projects.

Plant Genus	**Common Name**	**Approximate Bloom Time**		
		Early	**Mid**	**Late**
Cirsium	Native Thistle		■	■
Lupinus	Lupine	■	■	
Trifolium	Native Clover	■	■	
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	Fleabane/Aster		■	■
Aquilegia	Columbine	■		
Pedicularis	Lousewort	■	■	
Mahonia	Barberry	■	■	
Ribes	Currants/Gooseberries	■	■	
Arctostaphylos	Manzanita	■		
Salix	Willow	■		

Pollinator Plants: Maritime Northwest Region
https://xerces.org/publications/plant-lists/pollinator-plants-maritime-northwest-region

This Xerces Society fact sheet features recommended native plants that are highly attractive to pollinators such as native bees, honey bees, butterflies, moths, and hummingbirds, and are well-suited for small-scale plantings in gardens, on business and school campuses, in urban greenspaces, and in farm field borders.

Plant Species for Pollinator Habitat in the Inland Pacific Northwest
https://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/wapmcpo9185.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://www.xerces.org/publications/plant-lists/biology-technical-note-no-24-plants-for-pollinators-in-inland-northwest

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.

Plants for Pollinators in the Intermountain West
https://www.blogs.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/idpmctn13085.pdf

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 Intermountain West; encompassing southern Idaho, eastern Oregon, northern Nevada, and northern Utah.

Native Plant Profiles and Lists
https://www.wildflower.org/collections/

The Xerces Society has collaborated with the Lady Bird Johnson Wildflower Center to create plant lists that are attractive to native bees, bumble bees, honey bees, and other beneficial insects, as well as plant lists with value as nesting materials for native bees. These lists can be narrowed down with additional criteria such as state, soil moisture, bloom time, and sunlight requirements.

Appendix D: Additional Resources

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

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 Assessment Guide for Pollinators: Natural Areas and Rangelands
https://xerces.org/publications/hags/natural-areas-and-rangelands

This pollinator habitat assessment guide is designed for natural areas and rangelands.

Habitat Instillation

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 (327) 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 (NRCS Conservation Practice 327). Seed mixes and plant recommendations are included in the appendix of each guide.

Western Oregon & Washington Hedgerow Planting (422) 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 (NRCS Conservation Practice 422). 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 (IPM), 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.

How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees 2nd edition
https://xerces.org/publications/scientific-reports/how-neonicotinoids-can-kill-bees

Neonicotinoids are a group of insecticides used widely on farms and in urban landscapes. They are highly toxic to bees and can be taken up into plant pollen and nectar. This report provides an overview of research on neonicotinoid impacts on bees and recommendations to protect pollinators for policy makers, applicators, and the public.

Honey Bees

An Overview of the Potential Impacts of Honey Bees 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 honey bees to native bees (including bumble bees) and their habitats. It covers the potential effects of honey bees through competition with native bees and disease transmission, as well as the potential effects of honey bees on native plant populations and other wildlife.

Appendix E: Survey Protocol

Where
Bumble bees inhabit a wide variety of natural, agricultural, urban, and rural habitats, although species richness tends to peak in flower-rich meadows of forests and subalpine zones. See species profiles above for details on habitats and plant genera associated with the bumble bee species highlighted in this document.

When
Time of year: Across their range, bumble bees are generally active from spring through fall. See species profiles above for details on the active period of the bumble bee species highlighted in this document.

Daylight and temperature: Adults are active based on daylight and temperature. Conduct surveys between mid-day and late-afternoon (11am - 5pm, with the exception of very hot areas where surveying may occur before 11am) when temperatures are generally between 60-90 degrees Fahrenheit.

Cloud cover: Partly cloudy or better. On cooler days the sun can play a very important role in getting bees to take to the air. On warmer days (above 60 degrees F), direct sunlight is less important.

Wind: Less than 10 MPH. On windy days, bumble bees will shelter if they cannot maintain their direction and/or speed of flight.

Precipitation: No precipitation.

How
Conduct surveys in areas with relatively high floral abundance and species richness compared to the surrounding landscape. We recommend surveying a one-hectare area (equivalent to a 100 m by 100 m square, 2.5 acres, or a standard football field) for a total of 45 person minutes. Rectangular survey areas covering one hectare may be used if the geometry works better. A single surveyor requires 45 minutes to complete a survey, while two people can complete a survey in 22.5 minutes, and three only require 15 minutes.

Before conducting a survey, record information on the site and weather conditions. This includes latitude and longitude, time, surveyor(s), temperature, cloud cover, and wind speed. Note the survey start time, begin your timer, and start searching for bumble bees. While surveying, cover the full area while focusing the most time on areas with high relative floral abundance. Scan for any bumble bee activity, as well as suitable habitat. Bumble bees are predominantly encountered nectaring at flowers, and can be detected visually or acoustically when flying from flower to flower. Keep an eye out for bees visiting inconspicuous flowers that are green, small, or low growing. While looking for inconspicuous flowers, also look for bees flying close to the ground that may be searching for a nest. Nesting features include abandoned rodent burrows and other natural or manmade cavities, including in clumps of grass (e.g., bunchgrasses), hollow logs, and brush/rock piles. Nests are difficult to find, however if a nest is located, make a note of it and when possible, collect a bumble bee associated with the nest. Collect information on nest location, substrate, slope, and aspect.

When approaching a foraging individual, one strategy is to place the net over the entire plant, and, ensuring a good seal with the ground, agitate the net to encourage the bee to leave the plant and fly into the top of the net. Alternatively, swing the net from the side, scooping the bee into the net. For either strategy, swift movements and taking care not to cast a shadow over the bee yield best results. After capture, quickly flip the top of the net bag over to close the mouth and prevent the bee from escaping. Once netted, most insects tend to fly upward, so hold the mouth of the net downward and reach in from below when retrieving the bee. Place each captured bee into an individual, transparent, vial. Pause the timer each time you capture a bee and restart it once you finish processing the bee and begin searching again. Mark the vial using a unique identifier and take a photo of the vial with the plant that the bee was associated with. If the bee was not associated with a plant, note its activity (flying between flowering plants, flying close to the ground, etc.). In sites with many bumble bees that are clearly the same species, there is generally no need to capture more than 10 individuals of each species. Place each vial in a cooler packed with ice (do not use "blue ice" or other chemical chilling agents, ice cubes are the most effective method). The ice will cool off the bees enough that their movements are slowed, and you can clearly photograph them.

Once you have completed your survey (having searched a hectare for a total of 45 person-minutes), photograph each bee that you captured. Remove a single bee at a time, first ensuring that the bee is either not moving or only moving very slowly and take at least three photos that document the full color pattern on the bees' face, thorax, and abdomen, the hind leg, and the cheek. Ensure that photos are in focus and close up.

Record the photo numbers and plant associations on your data sheet. The species identification can be filled in later. When photographing is complete, release the bee in a warm, shady spot. 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.

Next, identify each bumble bee captured during the survey. If the surveyor is not comfortable identifying bumble bees, submit the photos to either a taxonomist or to an individual trained in bumble bee identification.

Surveying a site multiple times, on separate days during the peak period, increases the chance of detecting *Bombus* species that are using the area.

Recommended Survey Materials

- Map of the area
- GPS or smart phone with GPS capability
- Data sheets (or a notebook) and a pencil
- Camera with macro function or smart phone

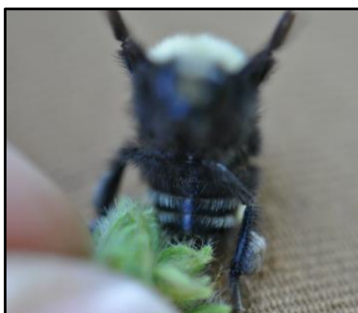
- Insect net
- Small cooler with ice
- Vials
- Materials for sanitizing vials (alcohol, alcohol wipes, or diluted (10%) bleach solution)
- Bumble bee ID materials
- Plant ID materials

Key Photos to Include

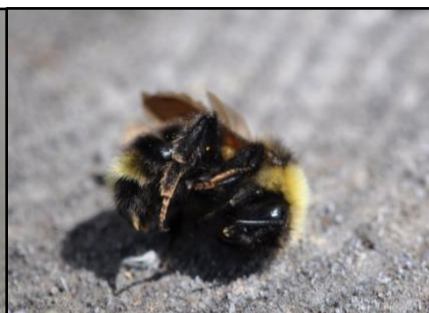
Sometimes you can capture a single photo that has many of these features. These are the best photos!

A photo that shows the color banding pattern on the thorax and abdomen is needed (note: you can also see the head, face, and cheek length in this angle).

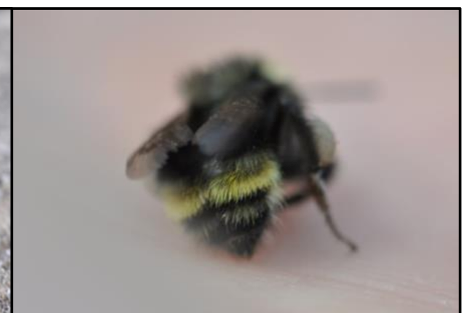
A photo that shows the head and face - including cheek length is very helpful.



For yellow faced - yellow striped bumble bees - a photo of the underside of the abdomen is necessary - note the yellow hairs visible in this photo.



Having a photo of the hind leg in focus can be very helpful for determining if it is a cuckoo bee, and determining male vs. female.



Sometimes a photo showing the tip of the abdomen can be helpful.

Photos by the Xerces Society.

Appendix F: Detailed Methods

Data

Occurrence records were sourced from a database of more than 700,000 records of 43 species of North American bumble bees compiled from various collections, research projects, and other datasets, developed and maintained by Leif Richardson (Richardson 2022). Many recent records were collected as part of the Pacific Northwest Bumble Bee Atlas (Xerces Society et al. 2022). 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 Oregon, Washington, and Idaho.

Assumptions

Selecting priority management areas based on known occurrences of a species presents challenges when addressing the conservation needs of bumble bee species. Given that bumble bees are physically small and spend a significant portion of their life cycle (Figure 2) in nests and hibernacula, we can assume that many populations of bumble bees, and particularly rare bumble bees, have not been detected. While the Pacific Northwest Bumble Bee Atlas has increased the number of bumble bee records collected, only a small fraction of the state's suitable habitat has been surveyed. Additionally, bumble bee records tend to be clustered around human population centers as a result of high sampling effort. Despite the tendency towards clusters of occurrence records near population centers, we assume that bumble bee habitat is broadly distributed across the state. We therefore conclude that selecting priority management areas based on known occurrences alone would significantly limit conservation opportunities.

While a number of the species included in this conservation strategy only overlap with Washington state at the edge of their ranges (frigid, golden-belted, and American bumble bees), these species have been included under the assumption that changes in environmental variables driven by climate change will likely continue to result in range shifts. Creating and maintaining habitat suitable for these species, even on the margins of their current ranges, will increase the likelihood of species persistence.

Selection Criteria for High Priority Areas

We used level IV ecoregions as the unit of data analysis and priority area selection. Level IV ecoregions are ecologically relevant units at a scale that allows for feasible analysis while also providing the specificity required for developing effective management recommendations. Washington state is composed of 57 level IV ecoregions (Figure 4). Following the selection of priority areas delineated by level IV ecoregions, we selected independent boundaries based on land cover to guide management.

Due to the limitations of identifying priority areas based on recorded observations alone, we identified priority areas by modeling species distribution. 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) takes into account recent 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 used presence only data because comprehensive absence data was not available, and for the majority of species, and particularly rare species, presence only models like MaxEnt perform as well as other types of models including occupancy models built using presence and absence data (Jha et al. 2022).

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 SDM. We defined thresholds below which predicted potential geographic 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). The predictor variables contributing the most to model fit provide information on what factors may drive the distribution of each species. Results of these SDMs 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. We conducted an additional analysis of land use and potential threats to provide a more complete representation of the potential forces shaping the current and future distribution of these species.

SDMs can be interpreted as the probability that a species occurs in any given area, or as the distribution of habitat suitable for a species. We modeled predicted potential geographic distribution for all eight species of interest for both the recent (2011-2021) and historic (2010 and earlier) time periods (Figure A 3, Figure A 5, Figure A 7, Figure A 9, Figure A 11, Figure A 13, Figure A 15, Figure A 17). We then calculated the mean predicted probability of presence by level IV ecoregion for each species separately and for the combination of all focal species included in this document. We determined the priority of level IV ecoregions by dividing the mean predicted probability of presence for all focal species into three categories, “low”, “medium”, and “high” (Figure 1), using Jenks natural breaks optimization (Jenks 1967).

For the eight focal species, high priority areas based on the mean predicted potential geographic distribution represent recent occurrence records fairly well (Figure A 1). However, some clusters of recent occurrence records fall outside of ecoregions identified as medium or high priority in our analysis. As these observations are significant, and to ensure that areas around known recent occurrences of focal species were explicitly incorporated in conservation opportunities, we mapped 10 km buffers around known recent occurrences for all eight focal species (Figure 5). We used 10 km buffers since this is approximately the farthest distance that bumble bees have been recorded to travel from their nest (Rao and Strange 2012, Williams et al. 2014), and has also been used by the FWS as the scale at which bumble bee populations exist (USFWS 2020). These ecoregions are generally occupied by a few species rather than a higher number of species, as is often the case with the medium and high priority ecoregions. We address ecoregions with a high number of occurrence records, but low priority ranking based on SDMs (Table 3) for all species separately.

While the average predicted potential geographic distribution for all focal species based on recent occurrence records provides a method for assessing the status of multiple species for a snapshot in time, considering the trend in average species distribution geographically can inform where limited conservation resources should be focused. We calculated the difference between historic (pre-2011) and recent (2011-2021) average predicted probability of species presence for medium and high priority level IV ecoregions.

Additional Management Opportunities

We grouped level IV ecoregions identified as medium and high priority for the conservation of the eight focal species included in this conservation strategy by land cover. A given ecoregion is included in a land cover grouping if more than ten percent of that ecoregion is composed of that land cover type. Level IV ecoregions may be included in multiple land cover categories if more than one land cover type covers 10 percent or more of the ecoregion. This categorization allows for the planning and implementation of more specific management actions depending on land cover and likely land use.

Current Land Cover

We assessed current land cover within each priority ecoregion by calculating the percent cover of each land cover type using modeled land cover (Dewitz and U.S. Geological Survey 2021). Determining the primary land cover in an area can be combined with potential threat factors to inform decisions about what management actions are most ecologically relevant. For example, management actions in an ecoregion primarily composed of evergreen forest may include thinning to open the canopy, increase herbaceous ground cover, and reduce the likelihood of high intensity fire. If an ecoregion is primarily shrub/scrub, management recommendations may focus more on reducing impacts to soil and protecting or restoring native vegetation that provide floral resources throughout the spring, summer, and fall.

Ownership and Management

Understanding the status of ownership and management of property in priority ecoregions allows for targeted management by federal and state agencies as well as potential outreach to other owners of land in priority areas including private owners and Tribal Nations. We calculated the percent of each priority ecoregion (Figure 10, Figure 11, Table B 13, Table B 14), number of occurrence records for all species of interest (Table A 1, Table A 2, Table A 3, Table A 4, Table A 5, Table A 6, Table A 7, Table A 8), and the predicted potential geographic distribution overlap of each focal species by land owner and manager. For the predicted potential geographic distribution overlap analysis we calculated the overlap of species predicted potential geographic distribution above the threshold identified in the species distribution modeling process with each level IV ecoregion.

Species Overlap by Ecoregion

We calculated the number of species potentially present in each medium and high priority level IV ecoregion for both the recent (2011-2021) and historic (pre-2011) time periods based on the results from SDMs (Figure 7). We considered a species to potentially be present in an ecoregion if any portion of its predicted potential geographic distribution, above the threshold determined during the species distribution modeling process, overlapped that ecoregion. Minimum thresholds for an area being considered part of a species' distribution vary by species, ranging from 13% (golden-belted bumble bee) to 37% (American bumble bee).

Potential Threats and Forces Shaping Ecosystems

Bumble bees face a variety of potential threats including exposure to pathogens from managed bumble bees and honey bees, impacts from reduced genetic diversity, habitat alterations including conifer encroachment, grazing, logging, exposure to pesticides, competition from managed bees, fire, agricultural intensification, urban development, and climate change. Understanding the relative impact of these factors across species' ranges, while identifying priority areas for conservation, informs on the ground management appropriate to regional conditions.

In order to characterize potential threats and their impacts across regions identified as priorities for the conservation of the eight bumble bee species included in this conservation strategy, we developed a threat matrix and analyzed those threats spatially. For potential threats with adequate available data we quantified mean value by level IV ecoregion and divided by the maximum value of that threat for each ecoregion to set the maximum end of the scale at one. We then calculated the mean of all potential threats by level IV ecoregion and again scaled the data so that the ecoregion with the highest potential threat score had a value of one, and all other ecoregions were scaled from zero to one.

While ideally an analysis would incorporate high quality data for all potential threats across the entire state, this data does not exist for all potential threats. In cases where relatively clean data does exist for a potential threat, there are a number of caveats that should be considered when interpreting results. First, depending on the scale and scope of the threat, many of them can range from a significant threat to benefit for bumble bees and their habitat. For example, the degree to which fire poses a threat to bumble bees depends on fire intensity, size, timing, and the time horizon for assessing impact. Some fires can cause long-term catastrophic damage, while others may generate beneficial habitat in the near- and long-term. Second, not all potential threats pose the same degree of threat to bumble bees, and not all threats nor how they interact with each other, are equally understood. Applying insecticides directly to a site with active bumble bees is an obvious threat. Seasonal grazing, or sublethal exposure to pesticides on the landscape present more nebulous threats that are difficult to measure, especially when combined. Finally, not all available data covers all jurisdictions. For example, while climate change impact can be modeled across the entire state of Washington, data on grazing allotments is generally only available for public lands, and the data available are largely presence/absence rather than quantified threats.

Because of the data and other limitations discussed above, we included the following potential threats in our spatial analysis: agriculture and development, grazing, fire, pesticides, and climate change. The 'Potential Threats to Species' section above provides information on additional threats that are important to understanding the distribution and conservation of these species.

Agriculture and Development

We estimated the potential threat posed by agriculture and development across the state using the land cover vulnerability to change model (Clark University 2021), which predicts human-based land cover changes and projects the extent of these changes to the year 2050.

Grazing

We assessed the effects of grazing on public lands using data on current and past grazing allotments on lands managed by the Forest Service (USDA Forest Service 2022) and Bureau of Land Management (Bureau of Land Management 2022). We included active and historic grazing allotments to estimate the spatial distribution of grazing threats in the past, present, and future. Our analysis of grazing only includes public lands grazing on Forest Service and Bureau of Land Management lands and does not consider grazing on private land or Tribal Nations. While grazing does occur on Washington Department of Fish and Wildlife land, this was not included in the analysis given the allotments cover a relatively small area.

Wildfire

We analyzed the probability of future wildfire using data from the Wildfire Hazard Potential dataset (Dillon et al. 2015). This dataset was generated from the LANDFIRE 2014 data by the USDA Forest Service, Rocky Mountain Research Station (Short 2017) using the large fire simulation system to predict annual burn probability and fire intensity. This analysis does not include prescribed burns.

Pesticides

We mapped pesticide use with the most recent data compiled by the U.S. Geological Survey estimating annual agricultural use of pesticides in counties of the conterminous United States in 2019 (Wieben 2021). From all pesticides, we created a subset for these analyses including insecticides and fungicides moderately and highly toxic to bees that were found to exceed regulatory limits in surface water in Washington State (Noland et al. 2021). This included the following active ingredients: Boscalid, Carbaryl, Chlorpyrifos, Clothianidin, Dimethoate, Fipronil, Imidacloprid, Malathion, Mycobutanil, Propiconazole, and Thiamethoxam. The low estimate of kilograms of each compound applied by county was summed by county. We then overlaid county data with level IV ecoregions and then used the average of summed pesticide application within each ecoregion to estimate overall pesticide impact. This evaluation of potential risk to bumble bees is limited in inference scope, as it only includes estimates from agricultural pesticide applications and not other varied uses, such as residential applications, vector control (mosquito management) applications, or applications to rangelands or forested areas. Non-agricultural applications make up a substantial proportion of pesticide use across the state, but there is limited information available on amounts or locations to which they are applied. Applications of agricultural insecticides in the form of seed coatings are also excluded from this analysis, as they are not currently regulated as pesticides by the US EPA despite widespread use in corn, soybeans, and other row crops.

Climate Change

We assessed the potential impact of climate change by analyzing the net change between historical and modeled future minimum temperature, maximum temperature, and precipitation. We used these factors as all three emerged as important factors in the SDMs that we build for the eight focal species. We sourced the data from the WorldClim database, a high spatial resolution global weather and climate dataset (WorldClim 2022). This database was also the source of climate and weather data used as inputs to the SDMs. We compared the average current minimum temperature, maximum temperature, and precipitation by level IV ecoregion from the historical time period (1970-2020) to projected future (2021-2040) values. Future climate projections were averaged across 24 models for two emission scenarios (ssp126 and ssp585). The difference between historic and projected future climate conditions for those 3 variables was then used to estimate potential climate departure, a measure of the threat posed by climate change.