Rusty Patched Bumble Bee (Bombus affinis)

Endangered Species Act Section 7(a)(2) Voluntary Implementation Guidance

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Rusty patched bumble bee Photo courtesy of Susan Day; University of Wisconsin-Madison Arboretum

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What's New in this Version

Significant updates to version 3.0 included:

- 1) We removed the section that provided guidance on estimating the density of overwintering queens. We decided that it was cumbersome and would produce estimates of questionable accuracy.
- 2) We added a suggestion, justification, and description for when 0.8 ha (2.0 acres) could be an appropriate threshold to determine when the extent of foraging habitat removal is likely to cause adverse effects to the species.
- 3) We added a determination key (Appendix A) that agencies may use to guide their project reviews. The key includes a form that users would submit to U.S. Fish and Wildlife Service to request concurrence on actions that may affect, but are not likely to adversely affect the rusty patched bumble bee, as determined by the key.

This version (3.1) includes only a minor correction – in Table 1, we modified the last row to clarify that certain 'cultural' habitats may function as foraging habitat during spring, summer, and fall.

Background and Purpose

In accordance with section 7(a)(2) of the Endangered Species Act (ESA), federal agencies must consult with the U.S. Fish and Wildlife Service (FWS) on any action that may affect species listed as endangered or threatened to ensure they do not jeopardize the species' continued existence. We intend for this voluntary guidance to help FWS, action agencies, and applicants carry out efficient and effective 7(a)(2)consultations and to plan and implement actions that would conserve the species.

The suggestions and alternatives provided in this document are subject to continual improvement and modification. Agencies may use any approach or methodology that ensures compliance with ESA Section 7 and implementing regulations at 50 Code of Federal Regulations Part 402. We encourage and expect deviation from these recommendations whenever appropriate to respond to distinct or differing conditions within an action area. We note that any use of mandatory language in this guidance refers to lawful obligations present in statute or regulation. This guidance does not bind agency personnel and does not create any new mandatory procedure or requirement for the public.

Current Version of this Guidance

Check to make sure that you have the most recent version by comparing the version number on the title page, above, to the guidance version number at the website, https://www.fws.gov/midwest/endangered/insects/rpbb/ProjectProponent.html.

Range, Status, and Recovery of the Rusty Patched Bumble Bee

The rusty patched bumble bee (*Bombus affinis*) occurs in the eastern and Midwestern United States and southern Canada. The species used to occur broadly across the eastern United States, upper Midwest, and southern Quebec and Ontario. Since about 2007 the species' distribution has declined across its range in the U.S. Similar declines have occurred in Canada where it was listed as Endangered on Schedule 1 of the Species at Risk Act in 2012 [U.S. Fish and Wildlife Service (USFWS) 2016]. For a map that shows the approximate current distribution of the species, see <u>this USFWS website</u>.

Section 7(a)(1) of the ESA directs each federal agency to carry out programs for the conservation of threatened and endangered species in consultation with the Service. The Service's recovery plan (USFWS 2021) and a pending recovery implementation strategy for the species will provide a basis for agencies to plan and implement actions that will help it fulfill their section 7(a)(1) mandate.

The recovery plan includes a phased approach to the species' recovery that focuses initially on halting and then reversing declines and ultimately, on securing the species' long-term viability. The recovery strategy's specific objectives include:

- Preventing further loss of populations by (a) identifying and ameliorating the threats driving the declines, (b) increasing the health of individuals and the number of colonies comprising populations, and (c) ensuring appropriate connectivity between populations.
- 2. Ameliorating pervasive threats, including those from pathogens, pesticides, habitat loss, managed bees, and effects of climate change.

- 3. Buffering against catastrophes and environmental stochasticity (may require reintroduction into unoccupied areas within the historical range) by increasing the number of genetically and demographically healthy populations and the spatial distribution of those populations.
- 4. Buffering against novel changes in the species' physical and biological environment by restoring populations across the breadth of its natural adaptive diversity.
- 5. Protecting populations and their habitats and abating threats into the foreseeable future.

Section 7 Consultation with USFWS

The recovery objectives for the rusty patched bumble bee provide an essential foundation for section 7(a) consultations. Under section 7(a)(2), federal agencies must ensure, in consultation and with the assistance of USFWS, that their actions are not likely to appreciably diminish the likelihood of a species' survival and recovery. The status of the rusty patched bumble bee as it relates to the recovery criteria and the way in which the proposed federal action is likely to affect the species' progress towards recovery are key factors that the action agency and the USFWS must consider when planning the project and assessing its effects, respectively. The first steps in this assessment are to evaluate whether and how the action may affect the species in the affected area.

Below we clarify steps that agencies and their representatives may take to meet ESA section 7(a)(2) requirements relative to the rusty patched bumble bee. We invite agencies to use any alternative methodologies that meet these same ends.

Step 1. Define the Action Area

The action area is not only the immediate area involved in the action, but all areas that the action will affect directly or indirectly (50 CFR § 402.02). It is not always limited to the "footprint" of the action, but encompasses the biotic, chemical, and physical impacts to the environment resulting directly or indirectly from the action.

Step 2. Determine whether the rusty patched bumble bee is likely to be present in the action area.

Section 7 regulations require each Federal agency to review its actions at the earliest possible time to determine whether any action may affect listed species or critical habitat (50 CFR § 402.14). Below we provide two options for determining whether RPBB may be present in an action area. Option 1 involves the use of the USFWS IPaC website (https://ecos.fws.gov/ipac/). Agencies may use any alternative approach that accurately determines whether the species may be present in the action area.

Option 1 – Use the FWS Information for Planning and Conservation (IPaC) Website

IPaC looks for overlap between the action area, as entered by the user, and underlying species distribution data, in this case, rusty patched bumble bee High Potential Zones (HPZ). As shown below, users may enter coarse information for the area of interest – for example a state or a county – or a precisely defined action area.

Screening at the County or State Level

Agencies may first want to determine if a listed species is present in any county or state that their actions may affect. To obtain a list of endangered species that are likely to be present in a county or state, use the FWS Information for Planning and Conservation website (IPaC).

If the rusty patched bumble bee is *not* on the list of endangered species you generate in IPaC, the species is not likely to be present. Consultation under section 7(a)(2) is only required for federal actions that may affect listed species. In this event, we would advise the action agency to document the finding for its administrative record.

Screen a Precisely Defined Action Area

As an alternative or as a follow-up to screening at the state or county level, agencies may define the action area in IPaC more precisely. If the resulting IPaC query produces a species list that includes the rusty patched bumble bee, the species may be present in the action area [the action area overlaps with a <u>rusty</u> <u>patched bumble bee High Potential Zone (HPZ)</u>]. The agency may contact the FWS Ecological Services field office to obtain what information may be available regarding the location, extent, and quality of the species' habitat in the action area (see Step 3).

If the rusty patched bumble bee is not on the list of species generated for the action area by IPaC, it is not likely to be present in the action area and we would advise the action agency to document this finding for its administrative record. Consultation under section 7(a)(2) is only required for federal actions that may affect listed species.

Option 2 – Work directly with the FWS field office.

Agencies may sometimes prefer to work directly with FWS field offices or may have other established methods for screening projects that do not yet include the use of IPaC. In those cases, agencies may work directly with the <u>FWS Ecological Services Field Office</u> to determine whether their action area may overlap with the current distribution of the rusty patched bumble bee.

Surveys

If the action area overlaps with an HPZ, the agency may assume that the species is present in suitable habitat (Fig. 1) and proceed to Step 4 or it may complete a *Project Review* survey for the species. Before planning or conducting surveys, check the FWS website

(https://www.fws.gov/midwest/endangered/insects/rpbb/surveys.html) to be sure that you are using the most recent version of the survey protocols. See the section, *Rusty Patched Bumble Bee Habitat*, below for a description of what constitutes habitat for the species. The results of a Project Review survey, if they are negative and are carried out in accordance with the Project Review survey protocol could support an agency determination that the species is unlikely to occur in the action area. The action agency may conclude for any documented and valid reason that the species is not present in the action area. For example, an agency may document that their action area does not contain habitat for the species even when it overlaps with an HPZ (Fig. 1).

Among other things, USFWS survey protocols include four surveys spaced approximately equally in time from early June to mid-August and with sufficient effort to support a determination that the species is not likely present in the area surveyed (USFWS 2019). Negative survey results remain valid for projects initiated within one year of the survey. In those cases, USFWS considers the results valid for the duration of the project unless new information (*e.g.*, new positive surveys) suggests that the species is likely to be present in the action area. In that case, action agencies and the <u>FWS Ecological Service Field Office</u> should work together to ensure that the best available information is considered.





Figure 2. The same hypothetical High Potential Zone (HPZ) shown in Fig. 1. In this case, the area likely to be affected directly or indirectly by the proposed action – the action area – occurs partly inside the HPZ, but does not overlap rusty patched bumble bee habitat.

Step 3 - Evaluate the Potential Effects of the Action

If the rusty patched bumble bee occurs in the action area, the action agency should determine whether its action may affect the species and whether those effects are likely to be adverse. The section 7 regulations (50 CFR 402.02) define effects of the action as *all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action.*

Federal actions may affect the rusty patched bumble bee if any of its components or consequences affect a resource on which the species relies or if any component or consequence of the action may interact directly with the species. Effects to a species' resource needs that can lead to an adverse individual response are *stressors*. Stressors act indirectly on a species through impacts to the resources it needs to fulfill its life cycle. Crushing an individual with a construction vehicle is an example of a direct interaction.

Answers to these three sets of questions can help to frame up an analysis:

- 1. Could the action or its consequences affect the species' resource needs or interact directly with the species?
- 2. If the action or its consequences could affect the species' resource needs, will that lead to an adverse individual response?
- 3. Is any individual of the species likely to interact directly with any feature or activity associated with the action or its consequences? If so, will that lead to an adverse individual response?

The FWS National Conservation Training Center provides online resources to help assess the effects of actions by identifying stressors and potential direct interactions and their effects to the species https://nctc.fws.gov/courses/csp3153/resources/index.html).

Assisted Determination Key

USFWS has developed an assisted determination key (App. A) that may be used to help to determine the effects of proposed actions on the rusty patched bumble bee. See the key for instructions on its use.

Rusty Patched Bumble Bee Habitat, Ecology, and Life Cycle

Colony Establishment and Growth

Bumble bees live in colonies – cooperative groups that include the offspring of one female and one male. Healthy rusty patched bumble bee colonies are large and may include more than one thousand workers (non-reproductive females). The workers protect the colony, forage for nectar and pollen, and care for the young. Healthy colonies with many workers can produce dozens to hundreds of new queens (Macfarlane 1974; Macfarlane et al. 1994).

Initially, colonies include only foundress queens, but grow to include workers, males, and new queens. In spring, queens emerge from their overwintering chambers to initiate colonies, having stored sperm from mating the previous autumn to fertilize eggs. Access to blooming flowers and a suitable nesting site – typically a rodent burrow – enables the queen to rear the first workers on her own. A "continuous supply of floral resources is required to support the nest-founding stage…because each queen must forage for food as well as tend the nest, potentially limiting her mobility" (Lanternman et al. 2019). Colony survival and productivity relies on continual access to blooming plant species throughout the spring, summer, and

early fall and protection from outside threats. Workers facilitate the production of the males and queens, which disperse from the nest to mate with reproductive progeny from other colonies that comprise the population (Plath 1922, Macfarlane et al. 1994, Colla and Dumesh 2010). Before winter, the original (foundress) queen, workers, and males all die. Only the new queens, referred to as *gynes*, can overwinter to initiate new colonies in the spring.

Nests

Rusty patched bumble bee nests are typically one to four feet underground in abandoned rodent nests or other mammal burrows and occasionally at the soil surface or aboveground (Plath 1922, Macfarlane 1974). Among the 43 rusty patched bumble bee nest records cited by Macfarlane (1974), 95% were underground. Queens may locate abandoned rodent burrows by using olfactory or chemical cues (Lanternman et al. 2019).

A recent paper by Lanternman et al. (2019) summarized 451 observations of nest-searching behavior by queens belonging to nine bumble bee species. Rusty patched bumble bee was not among the species observed, but their observations may shed some light on the manner by which the species searches for nest sites:

"Several criteria by which bumble bee queens select nest sites have been proposed – that the site should require little preparation by the queen, be situated in well-drained soil, and be sheltered from the elements (Frison, 1922; Alford, 1969). The greater abundance of nest seeking queens found in transitional zones between wooded and open habitats in our study, along with the large numbers of queens investigating areas with dense leaf litter, fallen logs and other features of woody habitats, supports these criteria."

The authors observed queens searching for nesting sites in open grassland habitats, but nest-seeking queens favored woody transitional habitats over open habitats (Lanternman et al. 2019).

Locations of Wintering Queens

Little is known about the overwintering habitats of rusty patched bumble bee foundress queens, but based on observations of other species we assume that rusty patched bumble bee queens overwinter in upland forest and woodland (Table 1). Other species of *Bombus* typically form a chamber in loose, soft soil, a few centimeters deep in bare earth, moss, under tree litter, or in bare-patches within short grass" and may avoid areas with dense vegetation (Alford 1969, p. 156; Liczner and Colla 2019, p. 792). Overwintering habitat preferences may be species-specific and dependent on factors such as slope orientation and timing of emergence. Most queens in England in were found in well-drained soil, shaded from direct sunlight in banks or under trees, and free from living ground vegetation (Alford 1969, pp. 150-152). Queens have also been documented using loose compost in flower pots to overwinter (Goulson 2010, p. 11). A recent review of published literature shows that overwintering queens have been found mostly in shaded areas, usually near trees and in banks without dense vegetation (Liczner and Colla 2019). The only known documented overwintering rusty patched bumble bee queen, discovered in a maple oak-woodland (about 0.5 km into the woodlands) in Wisconsin in 2016, was found under a few centimeters of leaf litter and loose soil (B. Herrick, University of Wisconsin-Madison Landscape Arboretum, pers. comm. 2016).

Williams et al. (2019, pp. 2-3) provide the first paper on overwintering habitat for any bumble bee in western North America. They found all ten yellow-faced bumble bees (*B. vosnesenskii*) queens "burrowed beneath 3.5–5 cm of cypress tree litter in a thin layer of duff between needle litter and mineral soil". All were within 1.5 meters of tree trunks, directly shaded from sun, which is consistent with other

bumble bees studied in Britain (*e.g.*, Alford 1969). The only North American bumble bee overwintering documented prior to the Williams et al. study and the 2016 UW Madison Arboretum observation (B. Herrick, University of Wisconsin-Madison Landscape Arboretum, pers. comm. 2016), was of the eastern bumble bee (*B. impatiens*), which was found overwintering beneath sod in loose aggregations of individuals at a depth of 7 cm (Plath 1927, pp. 183-184).

Nectar and Pollen Resources

Rusty patched bumble bees need access to <u>both</u> nectar and pollen from spring to fall to support all stages of colony development. Nectar is a source of both carbohydrates (energy) and water, whereas pollen is the main source of proteins and lipids (fats) (USFWS 2016, p. 15; Vaudo et al. 2020). Bumble bees rely on some plant species for pollen and others for nectar, even during single foraging bouts (Plowright and Laverty 1984, p. 187). Availability of pollen, may limit population growth more often than shortages of nectar (Colla 2016, p. 413; Plowright and Laverty 1984, p. 187) and the number of queens that a colony can produce is related directly to pollen availability (Burns 2004, p. 150). Production of sexual offspring (new queens and males) can be limited in simple landscapes with a low availability of diverse and high-quality pollen sources, even if nectar carbohydrates are present in abundance (Requier et al. 2020). Some plant species may hold special importance for bumble bees due to their especially high value nutritionally and for immune-support (see https://www.fws.gov/midwest/endangered/insects/rpbb/plants.html).

Queens must locate nests where plant species diversity is sufficient to ensure that forage will be available throughout its long active season, from mid-March into October (MacFarlane et al. 1994, p. 5, USFWS 2021 unpublished data). Workers may forage up to about a kilometer from nests, but most likely stay within a few-hundred meters (Dramstad 1996, Osborne et al. 1999, Knight et al. 2005, Wolf and Moritz 2008, Rao and Strange 2012). Floral resources close to the nest "might be especially important during the establishment phase of a colony, when only few workers are available for foraging" (Herrmann et al. 2007). Woodland spring ephemerals whose flowering period coincides with the species' early spring emergence during this phase and colony growth in the spring may play an outsized role in the production of males and new queens later in the season (Colla and Dumesh 2010, p. 45-46; Requier et al. 2020, entire or p. X). Late-season flower abundance and diversity also helps maximize queen production (Bukovinszky et al. 2017, p. 316).

Rusty Patched Bumble Bee Habitat

To facilitate section 7 analyses, we divide rusty patched bumble bee habitat conceptually into nesting and wintering habitats and into a variety of foraging habitat types based on relative timing of pollen and nectar availability (Table 1). The locations of pollen and nectar sources for the rusty patched bumble bee may vary throughout the growing season. In an HPZ that contains both forest and grassland, for example, the species may forage primarily in forest in the spring and in grassland habitats in the summer and fall. We assume that the rusty patched bumble bee nests in upland grasslands and shrublands that contain forage during the summer and fall and as far as 30 meters into the edges of forest and woodland (Table 1). We also assume that the species winters exclusively beneath trees in upland forest and woodlands. Palustrine wetlands – vegetated wetlands traditionally called by such names as marsh, swamp, bog, and fen (Federal Geographic Data Committee 2013) – provide nectar and pollen, but are not suitable for nesting or overwintering (Table 1) due to their flooded or saturated soils.

Table 1. Habitats and their typical seasons of use by the rusty patched bumble bee (RPBB). Rusty patched bumble bee habitat is typified by natural or semi-natural vegetation and often contains <u>plants used by the species</u>. The species' use of flower gardens, certain cultivated cropland (e.g., sunflower fields), and similar areas in which forage is concentrated are exceptions to this rule.

Habitat Category	Nesting	Wintering	Spring Foraging	Summer and Fall Foraging	When RPBB May be Present North of 42°	When RPBB May be Present South of 42°	Comments and Examples
Upland Forest & Woodland – Interior		X			October 11 – April 9	October 11 – March 14	Includes Maple-Basswood; Oak-Hickory and other forest and woodland types; observations of overwintering bumble bee queens are mostly in shaded areas usually near trees and in banks without dense vegetation (Liczner and Colla 2019).
Upland Forest & Woodland – Interior			Х		April 10 until forage is unavailable	March 15 until forage is unavailable	Functions as foraging habitat when forage species are present and blooming. Duration of use varies due to a range in plant species composition and other variables.
Upland Forest & Woodland – Edge (30 meter edge)	x	х	х	X	All year	All Year	The interface between forested and nonforested habitats (Harper et al. 2005). We assume the edge influence extends 30 meters into forest.
Upland Grassland & Shrublands	x		Х	х	April 10 – October 10	March 15 – October 10	Native meadows, prairie, etc. – remnants and reconstructed grassland habitats; other examples include savanna, pine and oak barrens and old fields. Value to the RPBB likely to depend on the density and diversity of forage species.
Palustrine wetlands, excluding ponds, and other areas where forage is not present			Х	Х	April 10 – October 10	March 15 – October 10	Marsh, swamp, bog, fen, wet meadow, etc.; forested wetlands (e.g., Silver Maple - Floodplain Forest). RPBB is likely only present if, and when, nectar or pollen are available.
Flower gardens, certain cropland, and similar areas within one kilometer of natural or semi-natural vegetation.			X	Х	April 10 – October 10	March 15 – October 10	Cultural vegetation that provides floral resources; accessed by RPBB from nearby natural and semi- natural areas where they may nest or overwinter; RPBB is likely only present if, and when, nectar or pollen are available.

Natural or semi-natural vegetation¹ typifies rusty patched bumble bee habitats. We typically expect the species to nest only in habitats that contain natural or semi-natural vegetation (Table 1), but the species also forages in certain 'cultivated' habitats – sunflower (*Helianthus annuus*) fields, gardens, plant nurseries, etc. – and has been documented to nest in other areas where there was evidence of rodent activity (Boon et al. in prep). Reconstruction of a variety of natural habitats – e.g., native prairie (Tonietto et al. 2017, p. 711) – appears to hold significant potential to provide areas for foraging, nesting, and overwintering, depending on the habitat type restored. If forage species are present, for example, reconstructed prairies can become important nesting and foraging habitat for the species as soon as 2-3 years after seeding (Griffin et al. 2017, p. 650).

Behavioral Assumptions

Seasonal Activity

Based on a review of rusty patched bumble bee observation records, in most years, the rusty patched bumble bee may only be active above ground between about March 15 and October 10 and April 10 and October 10 south and north of 42° latitude, respectively (USFWS, unpubl. data). Although air temperatures may be conducive to activity later in the fall, cessation of flight "appears to be timed with the passing of native fall flowers" (Schweitzer et al. 2012, p. 6).

Daily Activity

The rusty patched bumble bee is active under a broad range of conditions, but remains inactive when conditions are too cold or rainy. A study that included four bumble bee species found minimum calculated air temperature for activities that ranged from 3.6 to 12.6°C. We don't have similar data for the rusty patched bumble bee, but we think it's reasonable to assume that the species could be active between dawn and dusk at temperatures as low as about 4°C (39°F) within the seasons described above. Bumble bees do not typically fly when conditions are foggy, rainy, or drizzling. Sunny days with low wind speeds (less than 8 mph) may be optimal, but they will fly during sub-optimal conditions.

Assuming Presence and Interpreting Species Records

When an action area overlaps with an HPZ, FWS recommends that an agency conduct a survey to develop adequate information to assess effects of the project to the species (see *Surveys*, above). Without adequate survey data, FWS will give the benefit of the doubt to the species and will assume it to be present in any suitable habitat (Table 1). In these cases, we recommend that agencies evaluate the nature, extent, and quality of habitat types present (see Table 1 and <u>Rusty Patched Bumble Bee Habitat</u> <u>Assessment Form & Guide</u> (Xerces Society 2017) to help assess the status of the species in the action area

¹ Vegetation where ecological processes primarily determine species and site characteristics; that is, vegetation comprised of a largely spontaneously growing set of plant species. Human activities influence these characteristics to varying degrees (e.g., logging, livestock grazing, fire), but do not eliminate or dominate the spontaneous processes. Wherever doubt exists as to the naturalness of a vegetation type (e.g., old fields, various forest plantations), it is classified as part of the natural/semi-natural vegetation. Semi-natural vegetation typically encompasses vegetation types where the species composition and/or vegetation growth forms have been altered through anthropogenic disturbances such that no clear natural analogue is known, but they are a largely spontaneous set of plants shaped by ecological processes. Includes areas planted to restore native plant communities. National Vegetation Classification Standard [Federal Geographic Data Committee (FGDC) 2008, p. 9.

and the effects of the proposed action. If surveys were conducted, agencies should consider implications of the methods used, including the extent of the area that was surveyed.

The rusty patched bumble bee may be present anywhere within High Potential Zones where there is suitable habitat, but the timing and nature of its presence and activities in these areas is dependent on habitat type (Table 1). See the section, *Rusty Patched Bumble Bee Habitat, Ecology, and Life Cycle*, above, for a description of suitable habitat.

Analyzing Effects of Actions

The USFWS recommends a two-step process to determine whether and how an action may affect a species: 1) determine whether the species will be exposed to one or more stressors caused by the action and whether it will interact directly with any component or consequence of the project; and, 2) determine how the species will respond when exposed to the stressors or as a result of the direct interactions. A stressor is any physical, chemical, or biological alteration of the environment (i.e., increase, decrease, introduction, or removal) that can lead to an adverse individual response. Stressors act indirectly on a species through impacts to the resources it needs to fulfill its life cycle. Direct interactions are methods or means by which an activity or structure acts directly upon individuals of a species. Examples include crushing, collection, vehicle strikes, burial, disease, or displacement.

USFWS has identified several factors that pose a risk to the rusty patched bumble bee and that agencies and their representatives should consider when evaluating potential stressors associated with federal actions. See Appendix B for a brief summary and USFWS (2016) for additional details.

Portions of HPZs may be unsuitable for the rusty patched bumble bee (Fig. 2). A project would not affect the rusty patched bumble bee if it only affects areas that lack the habitat (Table 1) and if none of the project's components or consequences will interact directly with the species. When this is the case, the action agency may conclude that their action will have no effect to the species and document this finding for its administrative record. When making this determination, we caution action agencies to define carefully the full extent of the action area to ensure they consider any effects of the action that may extend outside of the immediate project footprint.

Potential for Effects from Temporary or Permanent Forage Removal

Bumble bees do not store much pollen and nectar in their nests and, thus, must have continuous access to flowers with available pollen and nectar during their entire active season to maximize production of new queens (Williams et al. 2012, p. 1055). A major impact of habitat loss on bees is the loss of floral resources or a reduction in their diversity that causes seasonal restrictions in forage availability. Loss of floral resources and a reduction in their diversity has occurred primarily through conversion of lands to agriculture and urbanization, but also because of other factors that have altered habitats, such as suppression of wildfires. Conversion of natural habitat that is rich in floral abundance and diversity to farmlands, urban and suburban development, and other land uses are the primary causes of the loss of bumble bee habitat (Goulson et al. 2015, p. 2). Ongoing urbanization also contributes to the loss and fragmentation of natural habitats. Declines in spring forage critical to foundress queens in forests have been documented by Mola et al. (2021, p. 1431) in Illinois and similar declines could be occurring elsewhere in the range of the rusty patched bumble bee. They did not find similar declines in primarily mid-summer forage resources from within grassland and wetland habitats, although the overall extent of grassland habitats declined (Mola et al. 2021, p. 1431). Urban gardens that provide floral resources for bees are critical to their persistence in and around cities, especially if they contain important native plant species (Goulson et al. 2010, p. 1207; Goulson et al. 2015, p. 1255957-6).

Removal of forage resources from as little as two acres of rusty patched bumble bee habitat could result in adverse effects to the species, based on certain assumptions. We assume that most rusty patched bumble bee workers forage within 200 m (656 feet) of their nest based on the study of the closely related bufftailed bumble bee discussed above (Wolf and Moritz 2008, p. 422; see above). In the spring, queens have to maintain brooding temperatures in nests and so may also stay close to nests to forage (Evans and Raine 2014). Because rusty patched bumble bees have a limited area within which they can forage and because they must forage daily to support the colony, even a comparatively small loss of forage can affect a colony's health. Therefore, we assume that when foraging resources are removed or reduced in more than 5% of the area within 200 m (656 feet) of a nest, even temporarily, adverse effects are likely to begin to accrue to the colony. Five percent of a circular foraging area with a radius of 200 m (656 feet) would be about 0.6 ha (2 acres). Therefore, we would conclude that removal of rusty patched bumble bee foraging habitat that exceeds 0.6 ha (2 acres) is likely to adversely affect the species. The adverse effects would only be temporary, however, if foraging habitat that is equal or greater in quality or extent regrows in the affected area. Management of foraging habitat carried out at some times of the year would not result in a reduction in foraging resources – for example, when summer foraging habitat is burned in the autumn after October 10.

Potential for Direct Effects from Ground Disturbance - Nest Density Assumptions

When site-specific information for the rusty patched bumble bee is insufficient to estimate abundance, it may be useful to apply nest density estimates derived for a close relative, the buff-tailed bumble bee, to develop useful assumptions. These assumptions will help to analyze effects of federal actions in a structured and transparent manner. Researchers have used genetic analyses of tissue samples collected from wild workers to estimate nest density of several bumble bee species since about 2003. The rusty patched bumble bee has not been the subject of any completed studies of this type, but the closely related buff-tailed bumble bee has (Chapman et al. 2003 (as cited in Charman et al. 2010); Darvill et al. 2004; Dreier et al. 2014; Knight et al. 2005; Kraus et al. 2009; Wolf et al. 2012; Wood et al. 2015). Higher nest abundance using genetic techniques has been estimated for more common species. For example, colony abundance of the most abundant wild bumble bee species in the eastern United States, common eastern bumble bee (*B. impatiens*, Strange and Tripodi 2019), was estimated at approximately 135 per hectare (McGrady et al. 2021, p. 8).

Due to the uncertainty with applying estimates derived for another species, we propose using a range of assumed nest densities as opposed to a single estimate (Table 2; see Table 1 for an overview of nesting habitat). This may increase the odds that our analysis accurately reflects the actual density of the rusty patched bumble bee in the action area. The species is now rare at continental and regional scales, but was abundant and widespread historically (USFWS 2016, p. 4) and may still be present in some localities at densities similar to relatively common species. By basing our analyses on a range of assumed nest densities, we may capture the possibility that nests occur at what may be relatively high densities in the action area.

Table 2. Quartiles for ten nest density estimates for the buff-tailed bumble bee (*B. terrestris*) (Chapman et al 2003 (as cited in Charman et al. 2010); Darvill et al. 2004; Dreier et al. 2014; Knight et al. 2005; Kraus et al. 2009; Wolf et al. 2012; Wood et al. 2015). As a basis for analyzing the effects of actions on the rusty patched bumble bee, we will assume that their nests may occur in nesting habitat at any of the three densities shown.

Quartile	Nest Density Category	Nest Density(Nests/km ²)
First/25 th Percentile	Low	14
Median/50 th Percentile	Medium	34
Third/75 th Percentile	High	45

Data from another rare bumble bee species – the precipitously declining great yellow bumblebee (*B. distinguendus*) – may indicate that our proposed assumptions for the rusty patched bumble bee are reasonable. Its nests occurred at an estimated density of 19/km² in a coastal grassland landscape (Charman et al. 2010). As with the studies conducted on the buff-tailed bumble bee, the authors estimated nest density for the great yellow bumble bee at the landscape scale. Estimated nest density would have been higher if it were estimated only for the specific portions of the landscape that were suitable for nesting. Like the rusty patched bumblebee, great yellow bumblebee relies "on the continued presence of flower-rich, unimproved grassland that provides floral resources throughout the colony cycle (June to September) and contains, or is close to, suitable sites for nesting, mating and hibernation." (Charman et al. 2010, p. 2671).

The nest density most appropriate for evaluating a project may depend on the nature of the effects that a project is likely to cause. When assumptions of this nature are made within the context of section 7 consultation due to a the lack of empirical information, we must give the benefit of the doubt to the species and therefore, either the Low or High levels of nest density may be the most appropriate. For example, when assessing the likelihood that ground disturbance during the nesting period will affect nests, we would give the benefit of the doubt to the species by basing analyses on the highest reasonable level of nest density -45 nest/km² if you rely on the buff-tailed bumble bee data summarized in Table 2.

Using Empirical Data to Estimate Site-Specific Nest Density

Agencies may use the methods summarized above to estimate nest density for the buff-tailed bumble bee in an action area. This would require capture of rusty patched bumble bees, removal of a leg tip, and genetic analyses. Action agencies who are interested in carrying out such a study should contact the USFWS.

Ground Disturbance in Nesting Habitat

The effects of ground disturbance² that affects more than 0.1 hectare (0.25 acre) of nesting habitat within an HPZ when the species is present may not be discountable. This is based on the assumption that rusty patched bumble bee nests may be present in nesting habitat at a density as high as $45/\text{km}^2$ (Table 2). That

² We define ground disturbance as any activity that compacts or disturbs the ground including, but not limited to, digging, seismic surveys, directional drilling, use of heavy equipment, grading, disturbance related to the construction, alteration, trenching, borrow pits, utility lines, bridges, development, some forestry activities, the placement of fill or spoil dirt, material stockpiling, blasting, or cultivation. A project will cause ground disturbance if it will leave depressions or wheel tracks on the soil, removal of forest floor layers, displaced soil, soil erosion, or soil compaction.

density is equivalent to one nest for every 2.2 ha (5.4 acres) of nesting habitat. At that density, and assuming that rusty patched bumble bees are equally likely to nest anywhere in the available nesting habitat, ground disturbance that exceeds 0.1 ha (0.25 acre)³ during the nesting season⁴ in nesting habitat would have a probability of destroying a nest that would exceed what we would consider to be discountable (i.e., 5%). The likelihood of destroying a nest would rise as the extent of nesting habitat subject to ground disturbance during the nesting season increases. This could occur, for example, if there are multiple projects in an HPZ, with multiple project proponents proposing actions that would cause ground disturbance in nesting habitat during the nesting season. USFWS would consider the potential for such additive impacts as part of its section 7 analysis.

Direct interactions with the species would only occur when the individuals are present in the affected area, but the agencies should also consider the potential for stressors to affect the species indirectly.

Rusty Patched Bumble Bee - Potential Stressors

In addition to the potential for direct interactions with the species, agencies must also determine whether components or consequences of their actions could cause effects to a species' resource needs that can lead to an adverse individual response (i.e., *stressors*). Agencies must base this determination on the best available information on the nature and extent of habitats in the action area and a full examination of the effect of the action. For any action that will affect an HPZ, the action agency can work with <u>FWS</u> to assess whether – and how – the action is likely to affect the species' resource needs. (See Appendix B and the next paragraph for a brief review of important risk factors for the rusty patched bumble bee and related stressors.) For a detailed review of the major stressors that agencies should consider when evaluating the effects of proposed federal activities on the rusty patched bumble bee, see the section **Risk Factors** in the <u>Rusty Patched Bumble Bee (Bombus affinis) Species Status Assessment</u> (USFWS 2016). For additional information regarding these stressors and measures to avoid or reduce relevant adverse effects, see the <u>Rusty Patched Bumble Bee Conservation Guidelines</u> (USFWS 2018).

Effects of the Action on the Species - Evaluating the Species Response to Stressors

After identifying the stressors and direct interactions to which the rusty patched bumble bee will be exposed, the action agency should determine the species' likely response to each relevant factor – that is, the likely effects of the action on the species. Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. (50 CFR § 402.02). This analysis of effects is the primary responsibility of the action agency, but FWS field office personnel can assist with this analysis. For a discussion of how a reduction in available forage – a common stressor – may affect the rusty patched bumble bee, see the section *Potential for Effects from Temporary or Permanent Forage Removal*, above.

 $^{^{3}}$ A density of 45 nests/km² is equal to 0.45 nests/ha. The probability that ground disturbance to 0.1 ha of nesting habitat would affect a rusty patched bumble bee nest, therefore, would be 0.045, assuming that nests are distributed uniformly in nesting habitat. We rounded 0.045 up to 0.05.

⁴ See rusty patched bumble bee nesting period dates at this website – USFWS: Rusty Patched Bumble Bee Guidance for Project Reviews. https://www.fws.gov/midwest/endangered/insects/rpbb/ProjectProponent.html

Step 4 - Incorporate Measures to Avoid or Minimize Effects to the Rusty Patched Bumble Bee

When the rusty patched bumble bee is likely to respond negatively to one or more stressors or direct interactions associated with the federal action or its consequences, the action agency or applicant may implement measures to avoid or minimize the adverse effects. Please refer to the <u>Rusty Patched Bumble</u> <u>Bee Conservation Guidelines</u> [see <u>ConservationGuidanceRPBBv1_27Feb2018.pdf (fws.gov)</u>].

When Adverse Effects Are Likely – Formal Consultation

When an action is likely to affect adversely the species, the action agency should request formal consultation. This is appropriate, for example, when agencies incorporate conservation measures into a project to minimize its effects, but some adverse effects are still likely. If the effects of the action is reasonably certain to include incidental take of the species, FWS would include an incidental take statement (ITS) with the biological opinion. The ITS would include terms and conditions that the agency or the applicant must follow to ensure that any take is not a violation of the ESA's section 9 prohibitions.

When Adverse Effects are not likely to Occur – Informal Consultation

When an action agency determines that its action may affect the rusty patched bumble bee, but is not likely to affect the species adversely, it may request concurrence from the FWS. Informal consultation would conclude with the written concurrence of the FWS [50 CFR § 402.13(a)].

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Appendix A. Rusty patched bumble bee assisted determination key.

Rusty-Patched Bumble Bee Assisted Determination Key

U.S. Fish and Wildlife Service, Version 1.1

Updated November 18, 2021

Purpose of the Key

The primary purpose of this assisted determination key is to help federal agencies and their non-federal representatives to determine whether their proposed actions may affect the rusty patched bumble bee (*Bombus affinis*); and, if they might, to facilitate consultation with U.S. Fish and Wildlife Service (USFWS) under section 7 of the Endangered Species Act. Although intended primarily for federal agency actions and section 7, it may also be useful for reviewing non-federal actions.

Use of the Key

The key is intended to function range-wide for any type of project. For some projects, it will allow the user to reach a determination of 'no effect' or 'may affect, not likely to adversely affect.' For others, the key directs the user to coordinate with a U.S. Fish and Wildlife Service Ecological Services field office (ESFO). Contact the local <u>ESFO</u> if you have any questions, concerns, or suggestions regarding the key.

How to Request Concurrence – Use of the Concurrence Request Form

To request concurrence from the USFWS on a determination of '*may affect, not likely to adversely affect*', submit a completed copy of the attached form to the local <u>ESFO</u>.

Versions of the Key

If you have accessed this key on the USFWS website, you are using the most recent version. If you are not, check <u>here</u> for most recent version. We intend for the key to be incorporated into the USFWS Information for Planning and Consultation (IPaC) webpage. Until that is done, we will keep the key on this webpage.

Determination Key

- 1) Does the action include or is it reasonably certain to cause *intentional* take of the rusty patched bumble bee? This could include, for example, surveys or studies that include handling or capture of the species.
 - a) Yes...... Review the <u>Rusty Patched Bumble Bee Guidance for Surveyors and</u> <u>Researchers</u> and secure an Endangered Species Act permit, if recommended by the guidance, Contact the <u>local USFWS Ecological Services Field Office</u> if you need additional information.
 - b) No..... go to 2
- 2) Will the action be authorized, funded, or carried out by the U.S. Forest Service for implementation on the Monongahela, George Washington, or Jefferson National Forest?
 - a) Yes..... go to 3
 - b) No..... go to 5

- 3) Does the action area⁵ overlap with a rusty patched bumble bee high potential zone?
 - a) Yes..... go to 6
 - b) No..... go to 4
- 4) Does the action include activities that the U.S. Fish and Wildlife Service and U.S, Forest Service have agreed will have wholly beneficial effects to the rusty patched bumble bee?
 - a) Yes..... The action may affect but is not likely to adversely affect the rusty patched bumble bee. Request concurrence on this determination from the <u>local USFWS</u> <u>Ecological Services Field Office</u>.
 - b) No..... The proposed action will have no effect on the rusty patched bumble bee; no consultation is required.
- 5) Does the action area overlap with a rusty patched bumble bee high potential zone? The proposed action overlaps with a rusty patched bumble bee High Potential Zone (HPZ) if the species appears on the species list generated by <u>IPaC</u> for the action area. A map that shows the locations of the HPZs is available <u>here</u>.
 - a) Yes..... go to 6
 - b) No..... The proposed action will have no effect on the rusty patched bumble bee; no consultation is required.
- 6) Does the action include or is it reasonably certain to result in construction of one or more new roads or rail lines; the addition of travel lanes to one or more existing roads; or other structures or activities that will increase vehicle traffic in a rusty patched bumble bee HPZ?
 - a) Yes.....contact the local USFWS Ecological Services Field Office.
 - b) No..... go to 7
- 7) Does the action include or is it reasonably certain to cause the use of commercial/managed bees (e.g., the use of honeybees or managed bumble bees to pollinate crops).
 - a) Yes..... Contact the local USFWS Ecological Services Field Office.
 - b) No..... go to 8
- 8) Is there habitat for nesting, foraging, and/or overwintering for the rusty patched bumble bee in the action area or will the proposed action restore habitat for the species in the action area? For a description of rusty patched bumble bee nesting and foraging habitats, see the <u>section 7 guidelines</u>.
 - a) Yes..... go to 9
 - b) No..... The proposed action will have no effect on the rusty patched bumble bee; no consultation is required.

⁵ Action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. (50 Code of Federal Regulations Part 402.02)

- 9) Have "Project Review" surveys for rusty patched bumble bees already been conducted in the action area according to <u>Service-approved protocols</u>?
 - a) Yes..... go to 10
 - b) No..... go to 11
- 10) Were rusty patched bumble bees observed during "Project Review" surveys (see definition in the <u>FWS Survey Protocols</u>)? Surveys must be consistent with FWS-recommended survey protocols with emphasis on recommended survey effort, timing, site selection, and survey technique and methods. Surveys must be conducted within a year before the project initiation for negative survey results to remain valid.
 - a) Yes..... go to 11
 - b) No..... The action may affect but is not likely to adversely affect the rusty patched bumble bee. Request concurrence on this determination from the <u>local USFWS</u> Ecological Services Field Office.
- 11) Does the action include collection of seed from native species?
 - a) Yes.....go to 12
 - b) No..... go to 14
- 12) Will the seed collection be carried out more frequently than once every three years in the same 2.0 acre (or larger) area?
 - a) Yes..... Consultation required. Contact the <u>local USFWS Ecological Services</u> <u>Field Office</u>.
 - b) No..... go to 13
- 13) Does the action include only seed collection and no other activities that could affect the rusty patched bumble bee or its habitat?
 - a) Yes.....The action may affect but is not likely to adversely affect the rusty patched bumble bee. Request concurrence on this determination from the <u>local USFWS</u> <u>Ecological Services Field Office</u>.
 - b) No..... go to 14
- 14) Does the action include, or will it cause the application of insecticides or fungicides; activities to control native rodent species; or planting or seeding of non-native plant species?
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services</u> <u>Field Office</u>.
 - b) No..... go to 15
- 15) Will the action include herbicide use?
 - a) Yes..... go to 16
 - b) No..... go to 17

- 16) Will herbicide application methods include only spot spraying (application to individual weeds using a hand-held sprayer) and/or other methods that include only applications to individual weeds (e.g., wick wiping, cut-stump, or basal bark treatments)?
 - a) Yes..... go to 17
 - b) No...... Consultation required. Contact the <u>local USFWS Ecological Services</u> <u>Field Office</u>.
- 17) Will the action cause an increase in the extent or duration of surface flooding or soil saturation in rusty patched bumble bee habitat in a High Potential Zone? This may occur, for example, as a result of activities or structures that impound water, otherwise alter or interrupt existing drainage patterns, or that affect surface runoff.
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services</u> <u>Field Office</u>.
 - b) No..... go to 18
- 18) Will the action cause ground disturbance⁶ in rusty patched bumble bee habitat within a High Potential Zone?
 - a) Yes..... go to 19
 - b) No..... go to 21
- 19) Will the action cause ground disturbance that affects more than 0.25 acre (0.1 hectare) of rusty patched bumble bee **nesting habitat** (upland grasslands, shrublands, and forest and woodland edges that contain native sources of pollen and nectar) in a High Potential Zone during <u>the nesting season</u>? For a more detailed description of rusty patched bumble bee nesting habitat, see the <u>section 7</u> guidelines.
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services Field</u> <u>Office</u>.
 - b) No.....go to 20

⁶ Ground disturbance means any activity that compacts or disturbs the ground including, but not limited to, digging, seismic surveys, directional drilling, use of heavy equipment, grading, disturbance related to the construction, alteration, trenching, borrow pits, utility lines, bridges, development, some forestry activities, the placement of fill or spoil dirt, material stockpiling, blasting, or cultivation. A project will cause ground disturbance if it will leave depressions or wheel tracks on the soil, removal of forest floor layers, displaced soil, soil erosion, or soil compaction.

- 20) Will the action cause ground disturbance² on more than 0.25 acre (0.1 hectare) of rusty patched bumble bee overwintering habitat (forest or woodland that contains native plants that provide pollen and nectar) in a High Potential Zone during the overwintering period? Go <u>here</u> to see overwintering period dates. For a more detailed description of rusty patched bumble bee overwintering habitat, see the <u>section 7 guidelines</u>.
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services Field</u> Office.
 - b) No.....go to 21

21) Will the action include or cause effects to vegetation in rusty patched bumble bee habitat?

- a) Yes.....go to 22
- b) No......The action will not affect the rusty patched bumble bee; no consultation is required.
- 22) Will the action cause effects to vegetation in rusty patched bumble bee habitat in the High Potential Zone during <u>the nesting period</u>? Effects could occur as a result of mowing, cutting, grazing, prescribed fire, tree removal, spot-application of herbicide, tree clearing, and/or other activities.
 - a) Yes.....go to 23
 - b) No.....go to 24
- 23) Will the action cause effects during <u>the nesting period</u> to 2.0 acres (0.8 ha) or more of foraging habitat? This excludes effects to vegetation in newly planted habitats *if they occur before the beginning of the third growing season after the initial seeding*. For a description of foraging habitat, see the rusty patched bumble bee section 7 guidelines.
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services Field</u> Office.
 - b) No.....go to 24
- 24) Does the action include the use of prescribed fire in forested habitat during the overwintering period? Go <u>here</u> to see the overwintering period dates.
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services Field</u> Office.
 - b) No.....go to 25
- 25) Will the action result in the permanent removal or conversion of any existing rusty patched bumble bee habitat at any time of the year?
 - a) Yes.....go to 26
 - b) No.....The action may affect but is not likely to adversely affect the rusty patched bumble bee. Request concurrence on this determination from the <u>local USFWS Ecological</u> <u>Services Field Office</u>.

- 26) Will the action result in the permanent removal of more than 2.0 acres (0.8 ha) of rusty patched bumble bee habitat at any time of the year?
 - a) Yes.....Consultation required. Contact the <u>local USFWS Ecological Services Field</u> <u>Office</u>.
 - b) No..... The action may affect but is not likely to adversely affect the rusty patched bumble bee. Request concurrence on this determination from the <u>local USFWS Ecological</u> <u>Services Field Office</u>.

Concurrence Request Form for Use with Assisted Determination Key

Use this form to request concurrence from the U.S. Fish and Wildlife Service for federal actions that may affect, but are not likely to adversely affect the rusty patched bumble bee, based on the use of the USFWS Assisted Determination Key.

Complete Table 1 and submit this form along with your request for concurrence to the local <u>ESFO</u>. Along with the form, include a brief description of the proposed federal action and a shapefile (preferred) or map of the area likely to be affected by the action (the action area⁷) along with your request for concurrence.

Table 3. Information for concurrence requests. RPBB = rusty patched bumble bee; HPZ = High Potential Zone.

Description of Action	Check if Applies	Acres RPBB Habitat Affected in HPZ
The action includes seed collection that will not affect the same 2.0 acres (or larger) area of RPBB habitat more frequently than once every three years.		
The action will include herbicide use in RPBB habitat within one or more HPZs, but only spot spraying (application to individual weeds using a hand-held sprayer) and/or other methods that include only applications to individual weeds (e.g., wick wiping, cut-stump, or basal bark treatments).		
The action will remove or convert RPBB habitat, but the amount of habitat removal or conversion is less than 2.0 acres. Ground disturbance in nesting habitat and in wintering habitat during the nesting and overwintering seasons, respectively, will not exceed 0.25 acres.		
The action will cause ground disturbance that affects <i>less</i> than 0.25 acre of RPBB nesting habitat (upland grasslands, shrublands, and forest and woodland edges that contain native sources of pollen and nectar) in a HPZ during the nesting season.		
The action will cause ground disturbance on <i>less</i> than 0.25 acre of RPBB overwintering habitat (forest or woodland that contains native plants that provide pollen and nectar) in a HPZ during the overwintering period.		
The action will cause effects during the nesting period to <i>less than</i> 2.0 acres (0.8 ha) of RPBB foraging habitat. Ground disturbance in nesting habitat during the nesting period will not exceed 0.25 acres.		
The action will affect 2.0 acres or more of <i>newly planted foraging habitat</i> during the nesting period, but only before the beginning of the third growing season after the initial seeding. Ground disturbance in nesting habitat during the nesting period will not exceed 0.25 acres.		

⁷ Action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

Appendix B. Partial list of potential stressors and responses associated with important rusty patched bumble bee risk factors.

We based the Potential Responses in part on studies of other bumble bee species with similar life history traits - generalist foragers that collect pollen from the same food sources. For more details on some of the following risk factors, see USFWS 2016.

Risk Factor	Potential Stressor(s)	Potential mode(s) of exposure	Potential Response(s)	Reference(s)
Pathogens and Parasites	Introduction, expansion, or increased abundance of honeybees or commercial bumble or other managed bees that carry pathogens	Collection and consumption of infected pollen	Larval mortality; queen sterility; deformed wings, abdomen distension in queens and inability to mate; reduced body fat and increased mortality of overwintering queens	USFWS 2016, p. 40-43
Insecticides	Insecticide applications	Consumption of contaminated nectar or collection of contaminated pollen	Decreased brain function; reduced feeding; decreased queen production; decrease male production; decreased worker production; increased worker mortality; decreased colony weight; decrease foraging efficiency (pollen delivery to nest); diminished defensive behavior; decreased worker weight; decreased egg production; decreased larval production; delayed nest building; impaired ovary development; increased susceptibility to parasite infection in queens	Feltham et al. 2014; Larson et. al 2013, p. 1; USFWS 2016, p. 43; p. 90-93
Insecticides	Insecticide applications	Direct contact/absorption	Contact mortality; Sub-lethal effects – e.g., reduced or no male production; egg infertility; reduced queen production	
Insecticides	Insecticide – Seed treatments	Consumption of contaminated nectar	Decreased queen production; decreased worker production; lower colony density; decreased colony weight	USFWS 2016, p. 90; Rundlöf et al. 2015, p. 79
Fungicides	Fungicide use	Reduced availability of nectar and pollen	Nutritional stress that leads to increased susceptibility to pathogens	Brown et al. 2000, p. 421; USFWS 2016, p. 42
Fungicides	Fungicide use	Increased transmission and prevalence of parasites due to reduced genetic diversity.	See responses to collection and consumption of infected pollen, above.	USFWS 2016, p. 42

Risk Factor	Potential Stressor(s)	Potential mode(s) of	Potential Response(s)	Reference(s)
		exposure		
Herbicides	Herbicide Use	Reduced availability of nectar and pollen	Nutritional stress that leads to increased susceptibility to pathogens; direct mortality	Brown et al. 2000, p. 421; USFWS 2016, p. 42; Straw et al. 2021, p. 5
Loss or Alteration of Vegetation or Leaf Litter	Loss of bunchgrasses and other vegetation that supports suitable nesting habitat	Limited or no nesting sites in proximity to summer foraging areas	Avoidance of area; deterioration in body condition and reduced reproductive output due to need to find appropriate nesting habitat elsewhere	
Loss or Alteration of Vegetation or Leaf Litter	Actions that directly or indirectly reduce or eliminate nectar plant density or diversity; examples include plowing, growing season fire; mowing; herbicide application	Inability to find suitable amounts of nectar and pollen.	Avoidance of area; potential deterioration of body condition and reduced or no reproductive output for affected queens; increased mortality of immature life stages already present in nests; reduced overwinter survival of queens	
Ground Disturbance or Compaction	Direct disturbance	Direct disturbance	Immediate death or harm of individuals present in nests or overwintering sites (queens);	
Ground Disturbance or Compaction	Compaction of soils by heavy equipment	Loss of potential nesting sites	Avoidance of area; deterioration in body condition and reduced reproductive output due to need to find appropriate nesting habitat elsewhere	
Ground Disturbance or Compaction	Construction matting or other temporary covering of ground surfaces	Temporary loss of potential nesting sites	Avoidance of area; deterioration in body condition and reduced reproductive output due to need to find appropriate nesting habitat elsewhere	
Competition for Resources from Commercial or managed bees	Reduced availability of nectar and pollen	Reduced availability of nectar and pollen	Negative effects on the reproductive success; Nutritional stress that leads to increased susceptibility to pathogens	
Competition for Resources from Commercial or managed bees	Disease transmission	See Pathogens and Parasites, above	See Pathogens and Parasites, above	