Rusty Patched Bumble Bee (*Bombus affinis*)

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

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U.S. Fish & Wildlife Service, Regions 3, 4, 5 and 6

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

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Contents

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 Versions 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 Conservation 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 occurred broadly across the eastern United States, upper Midwest, and southern Quebec and Ontario. Since about 2007, however, the species' distribution has declined across its range in the U.S. (Fig. 1). 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].

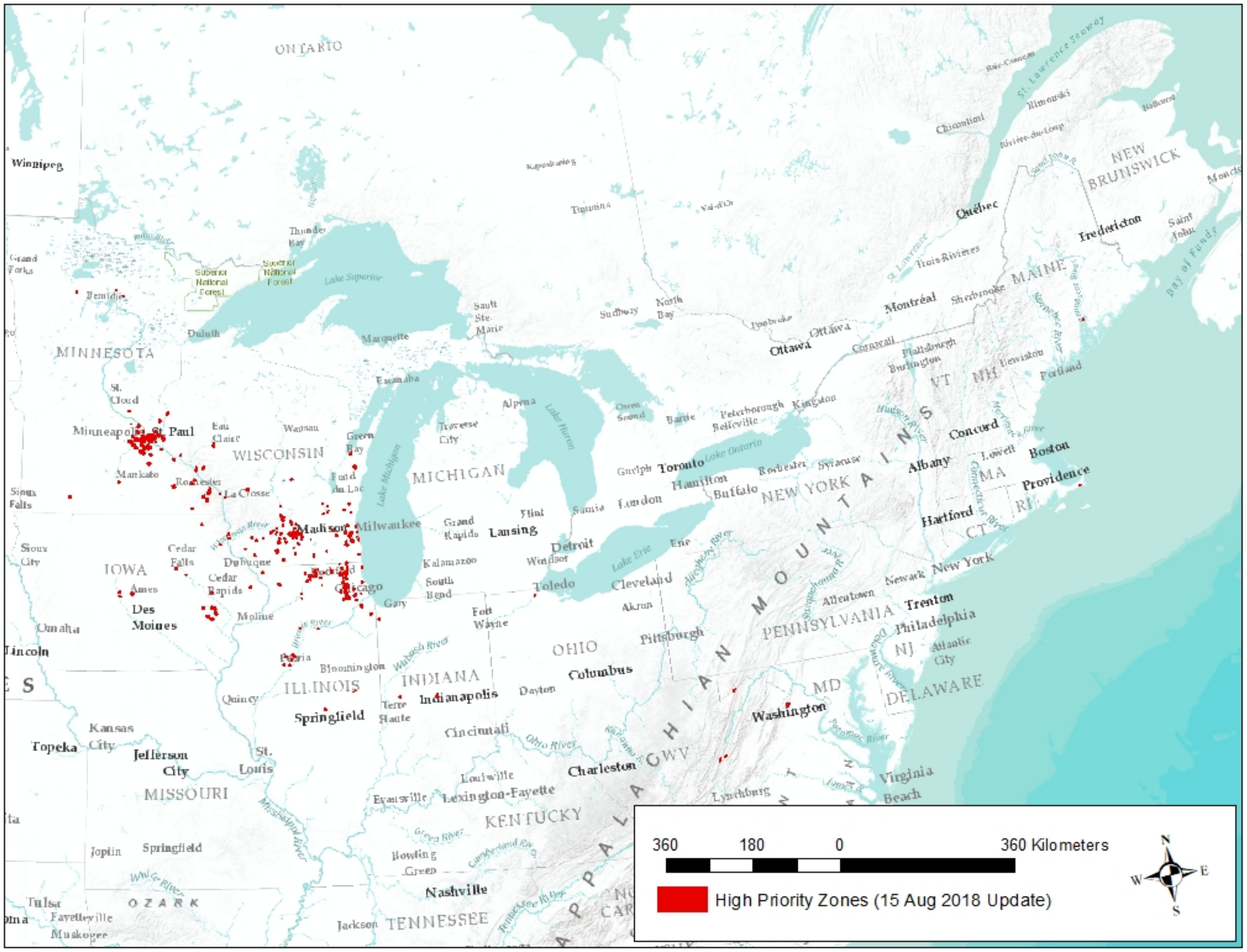

Figure 1.Rusty patched bumble bee High Potential Zones (HPZ). We increased the sizes of the HPZ polygons to enhance visibility. The Service maintains an up-to-date range map and distribution data for the rusty patched bumble bee at https://www.fws.gov/midwest/endangered/insects/rpbb/rpbbmap.html.

In its assessment of the species' status, USFWS (2016) found that to increase the likelihood that the rusty patched bumble may avoid extinction, it will be necessary to do the following:

1. Prevent further declines by protecting remaining populations and the habitat needed to support them (this is paramount);
2. Increase the number of healthy populations and ensure they are distributed across an array of environmental gradients;
3. Improve its abundance across the range of ecological settings with which it was associated historically; and,
4. Restore multiple, healthy populations to preserve adaptive capacity.

Section 7 of the Endangered Species Act and the Rusty Patched Bumble Bee

Screening and Evaluation of Federal Agency Actions – A Stepwise Approach

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

Determine whether the action area overlaps with a High Potential Zone (HPZ).[1] The action area is not only the immediate area involved in the action, but also all areas to be affected 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.

Below we provide two options for completing this step. Option 1 involves the use of the USFWS IPaC website (https://ecos.fws.gov/ipac/). Action 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 Website

Screening at the County or State Level

Agencies may first want to determine if a listed species is present in one or more counties or states that their actions may be 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, https://ecos.fws.gov/ipac/).

If the rusty patched bumble bee is *not* on the list of endangered species you generate in IPaC for the county or state that overlaps with the action area, the species is not likely to be present. Consultation

[1] We describe the habitat connectivity model used to define High Potential Zones on the RPBB website (https://www.fws.gov/midwest/Endangered/insects/rpbb/rpbbmap.html).

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 this finding for its administrative record (Fig. 3).[2]

Screen a Precisely Defined Action Area

As an alternative or as a follow-up to screening at the state or county level, you may define the action area in IPaC more precisely. If your IPaC query indicates that the rusty patched bumble bee is likely to occur in the action area, the action agency may contact the FWS field office to obtain what information is available regarding the location, extent, and quality of the species' habitat in the action area (see Step 3).

If the species 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 (Fig. 2). Consultation under section 7(a)(2) is only required for federal actions that may affect listed species.

[2] Each Federal agency shall review its actions at the earliest possible time to determine whether any action may affect listed species or critical habitat. (50 CFR 402.14).

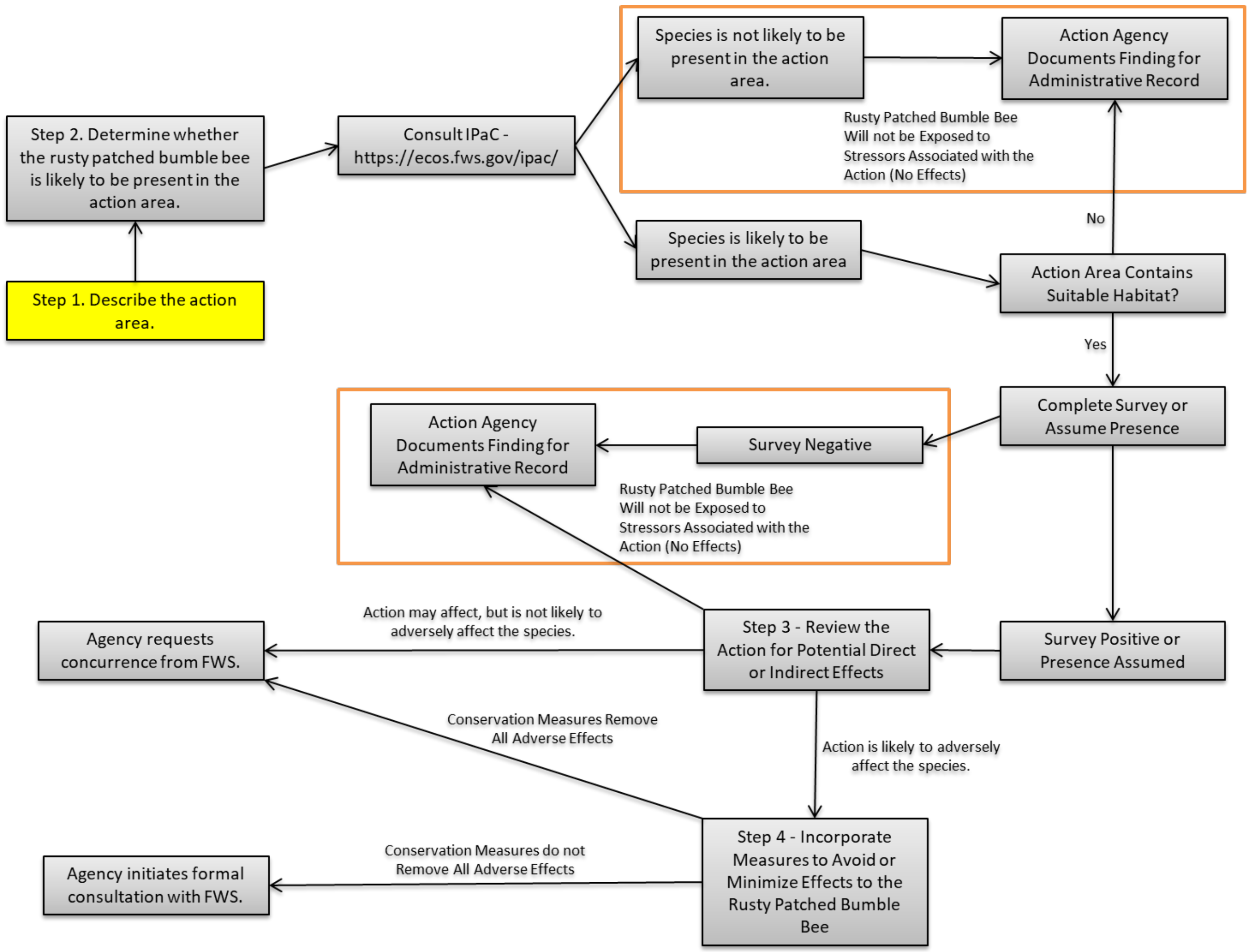

Figure 2. Consultation flow chart with specific reference to the rusty patched bumble bee.

Option 2 – Work directly with the FWS field office.

When agencies want to determine simply whether the rusty patched bumble bee is in a state or county, they should use IPaC. Agencies may also use IPaC to screen an action area based on its precise boundaries, as described above. 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 FWS field office 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. 3) and proceed to Step 4 or it may complete a survey for the species. (See the section, ***Rusty Patched Bumble Bee Habitat**,* below for a description of what constitutes habitat for the species.) The results of a survey, if they are negative and are carried out in accordance with FWS-recommended survey protocols, could support an agency determination that the species is unlikely to occur in the action area. The action agency may conclude for any documented reason that the species is not present in the action area if the administrative record contains the basis for its conclusion. Alternatively, for example, an agency may document that their action area does not contain habitat for the species even when it overlaps with one or more HPZ (Fig. 3).

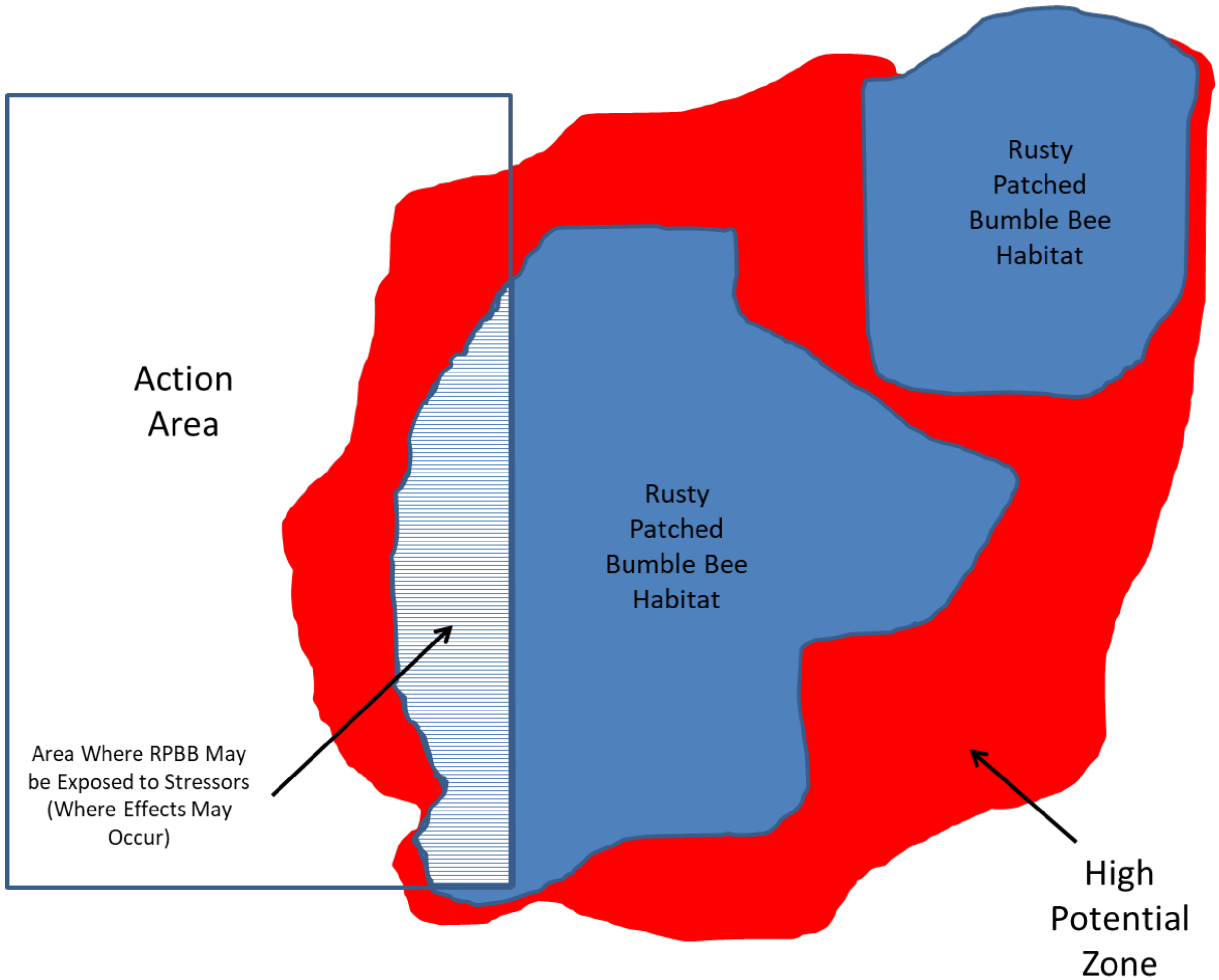

Figure 3. Example of a hypothetical High Potential Zone (HPZ) that contains areas with and without rusty patched bumble bee (RPBB) habitat. The species is only likely to be exposed to stressors associated with the action in the portion of the HPZ that contains the species' habitat.

We provide survey methods in "Survey Protocol and Monitoring Framework for Rusty Patched Bumble Bee (*B. affinis*)" (protocol, https://www.fws.gov/midwest/Endangered/insects/rpbb/surveys.html). Among other things, the protocol includes four approximately equally spaced surveys conducted during the sampling season (early June to mid-August) and with sufficient rigor[3] to support a determination that the species is not likely present in the area surveyed. Conduct surveys within a year before the project initiation for negative survey results to remain 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 FWS field office should work together to ensure that the best available information is considered.

Step 3 - Review the Action for Potential Direct or Indirect Effects

If the rusty patched bumble bee occurs in the action area, the action agency should determine whether its action may affect the species. This is a two-step analysis to address: 1) will the species be exposed to one or more stressors associated with the action; and, 2) how will the species respond to the relevant stressors. FWS is available to assist with this process.

The FWS National Conservation Training Center also provides online resources to help with this type of assessment https://nctc.fws.gov/courses/csp/csp3153/resources/index.html). In addition, the following information on the rusty patched bumble bee's key habitat features will help assess the potential for effects to the species.

Rusty Patched Bumble Bee Habitat, Ecology, and Life Cycle

To maintain abundant and healthy colonies, the rusty patched bumble bee requires access to a diverse array of plant species that collectively provide pollen and nectar throughout the species' long active season, from April through September (MacFarlane et al. 1994, p. 5). 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). Later in the season abundance and diverse floral resources help to maximize queen production (Bukovinszky et al. 2017, p. 316) and to ensure that gynes (new queens) get the resources they need to overwinter successfully.

Bumble bees are generalist foragers and gather pollen and nectar from a wide variety of flowering plants (Xerces 2013, pp. 27-28). The rusty patched bumble bee is a short-tongued species (Medler 1962, p. 214), which are generally more efficient at handling flowers with short or no corollas (Harder 1983). The rusty-patched bumble bee is also a confirmed nectar robber, occasionally cutting longer corollas tubes with their mandibles and accessing the nectar without tripping the flower's reproductive parts.

Species experts have identified several plant species that are likely important nectar sources for the rusty patched bumble bee (see https://www.fws.gov/midwest/endangered/insects/rpbb/plants.html). Nectar supports egg production in queens and is collected and fed to larvae by workers (USFWS 2016, p. 15). Limitations in pollen, however, may more often limit population growth than shortages of nectar (Colla

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[3] Sufficient effort would consist of four approximately equally spaced sampling periods during the sampling season (early June to mid-August); one-person hour of search time per three acres of suitable habitat using non-lethal netting techniques. The survey protocol provides further details on methods, techniques, and best practices (https://www.fws.gov/midwest/Endangered/insects/rpbb/surveys.html) and is subject to continual improvement and modification.

2016, p. 413; Plowright and Laverty 1984, p. 187). Bumble bees rely on some plant species for pollen and others for nectar, even during single foraging bouts (Plowright and Laverty 1984, p. 187) and the number of queens that a colony can produce is related directly to the amount of pollen that is available (Burns 2004, p. 150).

Bumble bee species typically foraging within a few hundred meters of their nest and maximum foraging distance may be about one kilometer (Knight et al. 2005, p. 1816; Wolf and Moritz 2008, p. 422; Dramstad 1996, pp. 163-182; Osborne et al. 1999, pp. 524-526; Rao and Strange 2012, pp. 909-911). In addition to open habitats, the species utilizes woodland spring ephemerals whose flowering period coincides with the species' early spring emergence (Colla and Dumesh 2010, p. 45-46).

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 the timing of pollen and nectar availability in each (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 adjacent forest and woodland (Table 1). We also assume that the species winters exclusively in upland forest and woodland. 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).

Table 1. Seasonal uses of habitat types by the rusty patched bumble bee (RPBB). Natural or semi-natural vegetation that includes favored forage species (Table 1) typifies RPBB habitat. The species also uses flower gardens and other areas that contain nectar or pollen resources and are within foraging distance of RPBB habitats. USFWS assumes that the RPBB is present in nesting habitat between March 16 and October 14 and in wintering habitat from October 15 to March 15.

Habitat Category	Habitat Function				Examples/Notes
	Nesting	Wintering	Foraging		
			Spring	Summer/Fall	
Upland Grassland & Shrubland	X		X	X	native tallgrass prairie, including remnants and restored/reconstructed native prairie; savanna; pine and oak barrens
Upland Forest & Woodland		X	X		Maple-Basswood Forest; Oak-Hickory Forest
Upland Forest & Woodland Edges	X	X	X	X	This includes 30-meter edges of forest and woodland habitats that are adjacent to nesting and summer/fall foraging habitat.
Palustrine wetlands, excluding ponds			X	X	marsh, swamp, bog, fen, and wet meadow; forested wetlands (e.g., Silver Maple - Floodplain Forest)
Some vegetation that is not natural or semi-natural – flower gardens and similar areas (e.g., plant nurseries)			X	X	Examples of cultural vegetation that provides floral resources; accessed by RPBB from nearby natural and semi-natural areas where they may nest or overwinter

Natural or semi-natural vegetation typifies rusty patched bumble bee habitats, with the exception that the species may also forage in nearby alfalfa (*Medicago sativa*) or sunflower (*Helianthus annuus*) fields, gardens, landscapes, and similar areas (e.g., native plant nurseries) that provide forage. Reconstruction of natural habitats holds significant potential to benefit the rusty patched bumble bee. The rusty patched bumble bee use reconstructed prairies (Tonietto et al. 2017, p. 711). If suitable species are present (see Table 1), reconstructed prairies may become important habitat for the species and other bees as soon as 2-3 years after seeding (Griffin et al. 2017, p. 650).

We use the term "natural or semi-natural vegetation" to characterize rusty patched bumble bee habitat and have adapted the following description from the National Vegetation Classification Standard [Federal Geographic Data Committee (FGDC) 2008, p. 9]:

> 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.

Areas that are not Rusty Patched Bumble Bee Habitat

The rusty patched bumble bee is not likely to be present in cultivated cropland, lawns, open water, or unvegetated areas with the exception that the species may forage in alfalfa or sunflower fields when these species are in flower and would provide pollen or nectar.

Behavioral Assumptions

To analyze some activities, it may be useful to understand the seasonal patterns of rusty patched bumble bee activity and the weather conditions that affect its behavior. During the active season, the rusty patched bumble bee is active under a broad range of conditions, but remains below ground when conditions are too cold or rainy. We do not know the precise lower threshold temperature for activity in the rusty patched bumble bee, but a study of four other bumble bee species found minimum calculated air temperature for activities ranged from 3.6 to 12.6°C. Therefore, it is reasonable to assume that rusty patched bumble bees could be active between dawn and dusk at temperatures as low as 3°C (37°F). 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.

The rusty patched bumble bee may only be active above ground between about March 15 and October 15. In the mid-Atlantic states, bumble bee records extended from about March 21 to about October 17 when average high temperatures in York, Pennsylvania – the approximate geographical center of the records –

were 12°C (54°F) and 19°C (66°F, respectively).[4] Cessation of flight in the fall "appears to be timed with the passing of native fall flowers and often precedes the first frost and leaf fall" (Schweitzer et al. 2012).

Evaluating the Species' Response to Project-Related Stressors

The USFWS recommends a two-step process to determine *whether* an action may affect a species and *how* that action will affect the species: 1) determine whether the species will be exposed to one or more stressors associated with the action; and, 2) determine how the species will respond to the stressors. A stressor is any physical, chemical, or biological alteration (i.e., increase, decrease, or introduction) of the environment (or resource) that can lead to a response from the individual. Stressors can act directly on an individual, or indirectly through impacts to resources.

Assessing the Species' Likely Response to Stressors

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 the Appendix for a brief summary and USFWS (2016) for additional details.

Will the Species Be Exposed to Project-Related Stressors?

In some cases, the species will simply not be exposed to stressors generated by the project or will not react to those stressors. HPZs typically contain some areas that are not suitable for the species. When this is the case, the action agency should 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.

Assuming Presence and Interpreting Species Records

When an action area overlaps with an HPZ, FWS recommends that an agency conduct a survey to clarify further the status of the species in the action area (see ***Surveys***, above). Alternatively, it may choose not to conduct surveys and to assume instead that the rusty patched bumble bee is present in any suitable habitat where the action area overlaps with the HPZ (Fig. 3). When action agencies assume that the species is present, they should review the following information to summarize the status of the species in the action area and to assess the effects of the proposed action:

- The nature, extent, and quality of habitat types present (see Table 1 and *Rusty Patched Bumble Bee Habitat Assessment Form & Guide* (Xerces Society 2017); and,
- Details of species records, such as the sex and caste of the bee(s) recorded (Table 2), the methods used to survey the area for the rusty patched bumble bee, and the extent of the area that was surveyed. Contact the FWS field office for this information.

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[4] Droege, S. 2008. Mid Atlantic native bee phenology: The weekly phenology of bees of the Mid-Atlantic states: MD, VA, WV, DC, PA, DE. A slideshow. USGS, Patuxent, MD. Available: http://www.slideshare.net/sdroege/midatlantic-native-bee-phenology.

Table 2. Rusty patched bumble bee records include at least four combinations of sex and caste, each of which may provide certain assumptions as part of section 7 effects analyses. See USFWS (2018) for information on how to identify the species and to distinguish each life stage.

Sex	Caste	Behavioral and Ecological Assumptions for Section 7 Analyses
Female	queen (foundress)	A queen recorded in the spring, if mated the previous year, was in the process of establishing a new colony. Mated queens detected before mid-July are foundresses.
Female	worker	A record of a worker indicates that there was a colony likely within one km of the detection point. Although worker foraging distances may extend out to 3 km in some species and circumstances (Lepais et al. 2010), studies typically exhibit foraging distances of less than 1 km from nests (Knight et al. 2005, p. 1816; Wolf and Moritz 2008, p. 422; Dramstad 1996, pp. 163-182; Osborne et al. 1999, pp. 524-526; Rao and Strange 2012, pp. 909-911).
Male	male	Males typically occur further from their natal nests than workers - up to about 10 km (Kraus et al. 2009, p. 249). We assume that a male record indicates that there was at least one colony of the species within 10 km of the record location.
Female	queen (gyne)	Queens observed after mid-July overwinter to become foundress queens in the spring. Lepais et al. (2010) found that queens of two bumble bee species were able to disperse at least 3 and 5 km, respectively; median dispersal distances were 1265 m and 1820 m.

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.

Potential for Direct Effects from Soil 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. Workers 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 of the studies, 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).

Due to the uncertainty with applying estimates derived for another species that is relatively common, we propose using a range of assumed nest densities as opposed to a single estimate (Table 3; see Table 1 for an overview of nesting habitat). This may increase the odds that we account for the capture the local status of the rusty patched bumble bee. 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 the species is either uncommon or relatively abundant in the action area.

Table 3. 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/25th Percentile	Low	14
Median/50th Percentile	Medium	34
Third/75th Percentile	High	45

The estimated nest density found for one rare bumble bee species – the precipitously declining great yellow bumblebee (*B. distinguendus*) – was 19/km^2 in coastal grasslands and may indicate that our proposed assumptions for the rusty patched bumble bee are reasonable for an endangered species. As with the studies conducted on the buff-tailed bumble bee, the estimated nest density for the great yellow bumble bee was for the studied landscape and may have been higher in the specific areas that were suitable for nesting. Its nests "remain thinly distributed even in current strongholds" (Charman et al. 2010, p. 2661). Like the rusty patched bumblebee, it 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 soil 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.

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.

Soil Disturbance in Nesting Habitat

The effects of soil disturbance 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, based on the assumption that rusty patched bumble bee nests may be present in nesting habitat at a density as high as 45/km^2. That is, one nest for every 2.2 ha (5.4 acres) of nesting habitat. We define soil disturbance as scraping, compacting, plowing, tilling, excavating, and any similar activity, *sufficient in intensity to kill or harm rusty patched bumble bees that are overwintering or in nests in the affected areas*. Soil disturbance in nesting habitat that is greater in extent than 0.1 ha (0.25 acre) would result in a greater than 5% chance[5] that a nest would be destroyed (e.g., see Fig. 4) – a level that would exceed what we would consider to be discountable when the impact would result in take of the species.

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[5] A density of 45 nests/km^2 is equal to 0.45 nests/ha. The probability that soil disturbance to 0.1 ha would affect a rusty patched bumble bee nest, therefore, would be 0.045, assuming that nests are distributed uniformly.

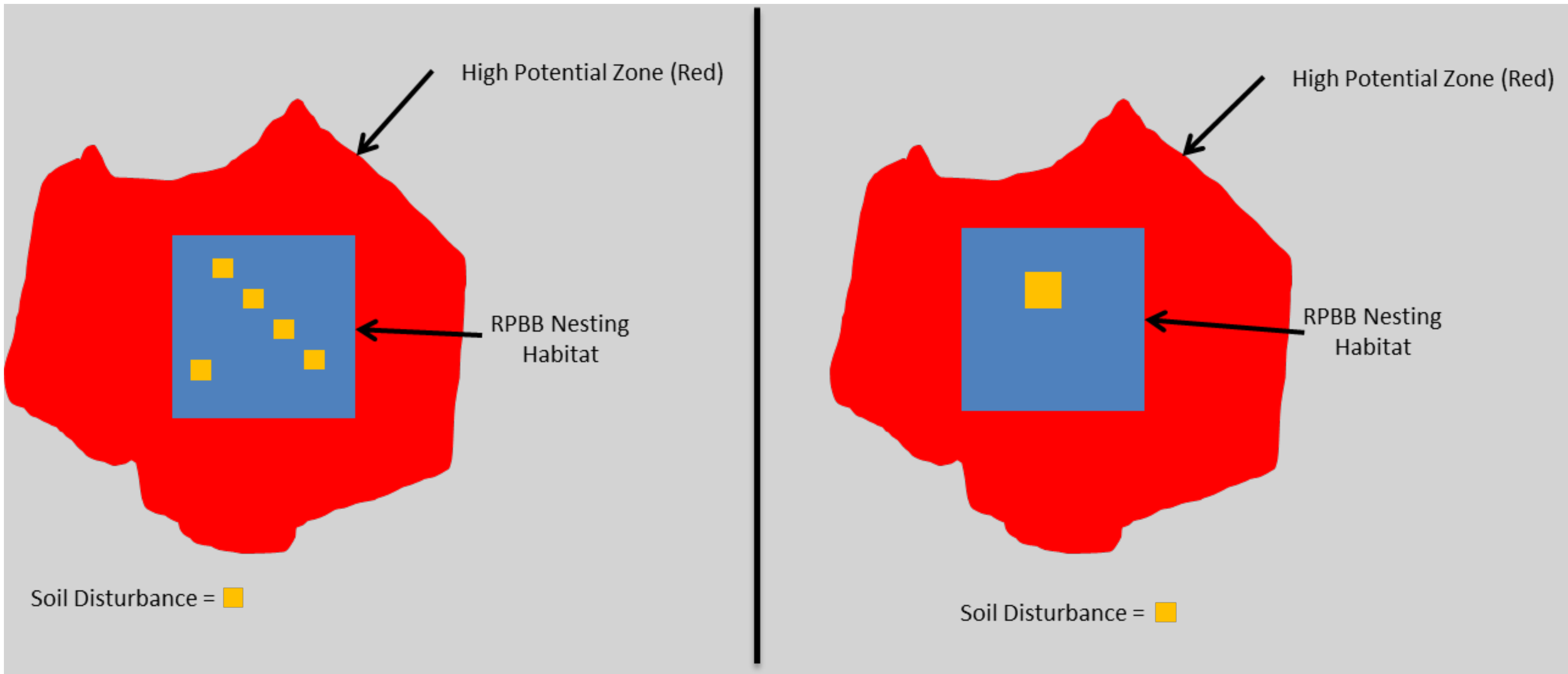

Figure 4. A hypothetical High Potential zone likely to contain one rusty patched bumble bee nest, based on an assumed nest density. In each example, 5% of the area will be exposed to soil disturbance sufficient in intensity to harm or kill nesting rusty patched bumble bees. This soil disturbance could occur in a series of separate patches (left) or as one contiguous area (right). In each case, the amount of surface area subject to soil disturbance would be sufficient to warrant a determination that the action is likely to affect adversely the species based on this guidance.

Direct effects to the species would only occur when the individuals are present in the affected area, but the agencies should also consider the potential for indirect effects to the species during seasonal absences from some habitats (see Table 1). Moreover, soil disturbance to nesting habitat may be likely to cause adverse effects even if the likelihood of directly affecting a nest is less than 5%. This may be the case, for example, when an action may destroy or degrade an area of especially high floral diversity. This must be determined on a case-by-case basis.

To evaluate the likelihood that an action would destroy one or more nests, we would assume that nests occur systematically across nesting habitat (Fig. 4).

Density and Distribution of Wintering Queens

If the federal action will result in soil disturbance in overwintering habitat when queens are present (October 15 – March 15), we also need a way to estimate the likelihood that one or more queens will be affected directly. We think that rusty patched bumble bee queens are likely to overwinter in upland forest and woodland (Table 1). They may construct their overwintering chambers immediately below the soil-litter interface in loose soil as has been observed for the closely related buff-tailed bumble bee and other species (B. Herrick, University of Wisconsin-Madison Landscape Arboretum, pers. comm. 2016; Alford 1969, p. 156).

To develop estimates of queen production for an HPZ we will use queen production data available from the yellow-banded bumble bee (*B. terricola*), another declining bumble bee species that is also closely related to the rusty patched bumble bee. These data include four lab-raised nests (Benjamin Sadd, Illinois State University, personal communication, 2018) and 32 field-reared nests studied by Owen et al. (1980). We may estimate Low, Medium, and High levels of queen production based on the 25th, 50th, and 75th percentiles from their studies – these are 0, 4, and 10 queens per nest, respectively. We decided to set the Low level at one queen per nest because it will be more useful for section 7 purposes than if we were to assume zero queen production. Using the Low, Medium, and High assumptions for both nest density and queen production, you may structure your analysis as is shown in Table 4 to arrive at a range of estimates of queen production in an HPZ for your analysis.

Table 4. Recommended Low, Medium, and High-level assumptions for queen production per nest, combined with Low-Medium-High nest density estimates (Table 3) to estimate a potential range of queen production per square kilometer (km) in an HPZ. 'x' = the number of square km of nesting habitat in the HPZ. To derive similar estimates for an action area, define x as the square kilometers of nesting habitat in the action area.

	Assumed Queen Production per Nest		
Estimated No. Nests in HPZ	*Low (1/nest)*	*Medium (4/nest)*	*High (10/nest)*
Low (14 nest/km^2)	14x	56x	140x
Medium (34 nests/km^2)	34x	136x	340x
High (45 nests/km^2)	45x	180x	450x

To model the number of overwintering queens present in an HPZ and to facilitate analyses, we recommend assuming that all queens produced in the HPZ remain there to overwinter and that the queens occur uniformly within the overwintering habitat. You may then calculate the assumed density of overwintering queens by dividing estimated queen production by the extent of overwintering habitat in the HPZ. This will allow an estimate of the likelihood that an overwintering queen is likely to be harmed or killed, based this model and the extent of soil disturbance that will occur in overwintering habitat when the species is present (October 15 – March 15).

When agencies and the Service make assumptions of this nature due a lack of site-specific empirical information, we must give the benefit of the doubt to the species. Depending on the nature of the anticipated effects, the Low or High level of queen production may be most appropriate. For example, when assessing a project that will include soil disturbance during the wintering period, give the benefit of the doubt to the species by basing analyses on the highest reasonable level of queen density.

Rusty Patched Bumble Bee - Potential Stressors

In addition to the potential for direct effects to the species, agencies must also determine whether indirect effects the species could occur and, if so, whether they are likely to be adverse. They must base this determination on the best available information on the nature and extent of habitats in the action area. For any action that will affect an HPZ, the action agency can work with FWS to assess whether – and how – the action is likely to affect key habitat features and how it may related to important risk factors. Those factors and their related stressors are described only briefly below and in the Appendix. 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 *Rusty Patched Bumble Bee (Bombus affinis) Species Status Assessment* (USFWS 2016). For additional information regarding these stressors and measures to avoid or reduce relevant adverse effects, see the *Rusty Patched Bumble Bee Conservation Guidelines* (USFWS 2018).

Predicting the Species' Response to Habitat-Related Stressors

Bumble bees do not store substantial amounts of pollen and nectar in their nests and, thus, must have continuous access to flowers with available pollen and nectar during their entire active season (Williams et al. 2012). The greatest impact of habitat loss on bees is the loss of floral resources or a reduction in their diversity. 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. 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).

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

After identifying the stressors that the rusty patched bumble bee will be exposed to, the action agency should determine the species' likely response to each relevant stressor – that is, the likely effects of the action on the species. This analysis of effects is the primary responsibility of the action agency, but FWS field office personnel may assist with this analysis.

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 associated with the action, the action agency may implement measures to avoid or minimize the adverse effects. Please refer to the *Rusty Patched Bumble Bee Conservation Guidelines* (see https://www.fws.gov/midwest/endangered/insects/rpbb/pdf/ConservationGuidanceRPBBv1_27Feb2018.pdf.)

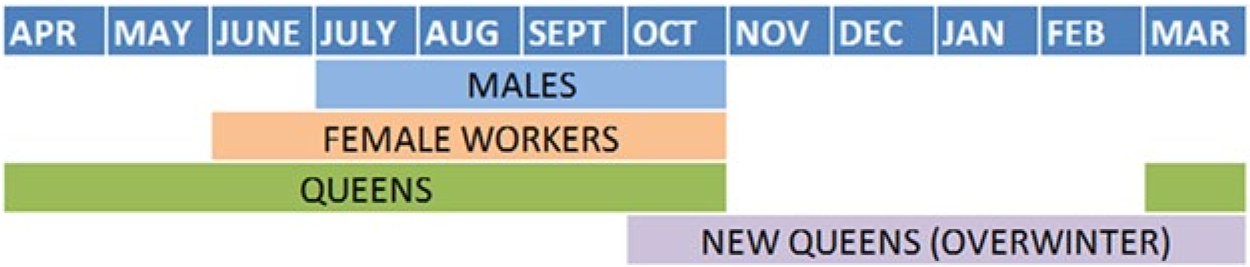

Figure 5. Rusty patched bumble bee phenology.

Conservation Measures

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. When the Service develops a recovery plan and a recovery implementation strategy for the species, these documents will provide a primary reference for agencies to implement actions that will help it fulfill its section 7(a)(1) mandate. Until then, we would recommend that actions address the major conservation needs of the species, as described in the Species Status Assessment (USFWS 2016, p. 74):

1. Prevent further declines by protecting remaining populations and the habitat needed to support them (this is paramount);
2. Increase the number of healthy populations and ensure they are distributed across an array of environmental gradients;
3. Improve its abundance across the range of ecological settings with which it was associated historically; and,
4. Restore multiple, healthy populations in each of its ecoregions.

Conservation Management Guidelines that may help action agencies to fulfill this mandate are available on the Service's website - https://www.fws.gov/midwest/endangered/insects/rpbb/index.html. Action agencies may also use these measures to remove or reduce adverse effects.

When Adverse Effects Are Likely

Agencies should enter into formal consultation with FWS if a project's conservation measures do not decrease sufficiently the likelihood of adverse effects. If the Service anticipates that the action will result in the incidental take of the species and is not likely to jeopardize the species' continued existence, it will include an incidental take statement (ITS) with the biological opinion. The ITS will include terms and conditions that the agency 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

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

Literature Cited

Alford, A. V. 1969. A Study of the Hibernation of Bumblebees (Hymenoptera:Bombidae) in Southern England. Journal of Animal Ecology 38: 149-170.

Brown, M. J. F., R. Loosli, and P. Schmid-Hempel. 2000. Condition-Dependent Expression of Virulence in a Trypanosome Infecting Bumblebees. Oikos 91: 421-427.

Bukovinszky, T., I. Rikken, S. Evers, F. L. Wäckers, J. C. Biesmeijer, H. H. T. Prins, and D. Kleijn. 2017. Effects of pollen species composition on the foraging behaviour and offspring performance of the mason bee Osmia bicornis (L.). Basic and Applied Ecology 18: 21-30.

Burns, I. 2004. Social Development and Conflict in the North American Bumblebee Bombus impatiens Cresson. University of Minnesota, St. Paul, MN. 211 p.

Chapman, R. E., and A. F. Bourke. 2001. The influence of sociality on the conservation biology of social insects. Ecology Letters 4: 650-662.

Charman, T. G., J. Sears, E. Green Rhys, and A. F. G. Bourke. 2010. Conservation genetics, foraging distance and nest density of the scarce Great Yellow Bumblebee (Bombus distinguendus). Molecular Ecology 19: 2661-2674.

Colla, S. R. 2016. Status, Threats and Conservation Recommendations for Wild Bumble Bees (Bombusspp.) in Ontario, Canada: A Review for Policymakers and Practitioners. Natural Areas Journal 36: 412-426.

Colla, S. R., and S. Dumesh. 2010. The Bumble Bees of Southern Ontario: Notes on Natural History and Distribution. Journal of the Entomological Society of Ontario 141: 39-68.

Darvill, B., M. E. Knight, and D. Goulson. 2004. Use of Genetic Markers to Quantify Bumblebee Foraging Range and Nest Density. Oikos 107: 471-478.

Dramstad, W. E. 1996. Do bumblebees (Hymenoptera: Apidae) really forage close to their nests? Journal of Insect Behavior 9: 163-182.

Dreier, S., J. W. Redhead, I. A. Warren, A. F. G. Bourke, M. S. Heard, W. C. Jordan, S. Sumner, J. Wang, and C. Carvell. 2014. Fine-scale spatial genetic structure of common and declining bumble bees across an agricultural landscape. Molecular Ecology 23: 3384-3395.

Federal Geographic Data Committee. 2013. Classification of wetlands and deepwater habitats of the United States. FGDC-STD-004-2013. Second Edition. Wetlands Subcommittee, Federal Geographic Data Committee and U.S. Fish and Wildlife Service., Washington, DC. 86 p.

Federal Geographic Data Committee, (FGDC). 2008. National Vegetation Classification Standard, Version 2. Reston, VA. 119 p.

Feltham, H., K. Park, and D. Goulson. 2014. Field realistic doses of pesticide imidacloprid reduce bumblebee pollen foraging efficiency. Ecotoxicology 23: 317-323.

Goulson, D., E. Nicholls, C. Botias, and E. L. Rotheray. 2015. Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. Science 347: 1255957.

Goulson, D., O. Lepais, S. O'Connor, J. L. Osborne, R. A. Sanderson, J. Cussans, L. Goffe, and B. Darvill. 2010. Effects of land use at a landscape scale on bumblebee nest density and survival. Journal of Applied Ecology 47: 1207-1215.

Griffin, S. R., B. Bruninga-Socolar, M. A. Kerr, J. Gibbs, and R. Winfree. 2017. Wild bee community change over a 26-year chronosequence of restored tallgrass prairie. Restoration Ecology 25: 650-660.

Harder, L. D. 1983. Flower Handling Efficiency of Bumble Bees: Morphological Aspects of Probing Time. Oecologia 57: 274-280.

Herrmann, F., C. Westphal, R. F. A. Moritz, and I. Steffan-Dewenter. 2007. Genetic diversity and mass resources promote colony size and forager densities of a social bee (Bombus pascuorum) in agricultural landscapes. Molecular Ecology 16: 1167.

Knight, M. E., A. P. Martin, S. Bishop, J. L. Osborne, R. J. Hale, R. A. Sanderson, and D. Goulson. 2005. An interspecific comparison of foraging range and nest density of four bumblebee (Bombus) species. Molecular Ecology 14: 1811-1820.

Kraus, F. B., S. Wolf, and R. F. A. Moritz. 2009. Male Flight Distance and Population Substructure in the Bumblebee Bombus terrestris. Journal of Animal Ecology 78: 247-252.

Larson, J. L., C. T. Redmond, and D. A. Potter. 2014. Impacts of a neonicotinoid, neonicotinoid–pyrethroid premix, and anthranilic diamide insecticide on four species of turf inhabiting beneficial insects. Ecotoxicology 23: 252-259.

Lepais, O., B. Darvill, S. O'Connor, J. L. Osborne, R. A. Sanderson, J. Cussans, L. Goffe, and D. Goulson. 2010. Estimation of bumblebee queen dispersal distances using sibship reconstruction method. Molecular Ecology 19: 819-831.

Macfarlane, R. P., K. D. Patten, L. A. Royce, B. K. W. Wyatt, and D. F. Mayer. 1994. Management potential of sixteen north american bumblebee species. Melanderia 50: 1-12.

Medler, J. T. 1962. Morphometric Studies on Bumble Bees. Annals of the Entomological Society of America 55: 212-218.

Osborne, J. L., S. J. Clark, R. J. Morris, I. H. Williams, J. R. Riley, A. D. Smith, D. R. Reynolds, and A. S. Edwards. 1999. A Landscape-Scale Study of Bumble Bee Foraging Range and Constancy, Using Harmonic Radar. Journal of Applied Ecology 36: 519-533.

Owen, R. E., F. H. Rodd, and R. C. Plowright. 1980. Sex Ratios in Bumble Bee Colonies: Complications Due to Orphaning? Behavioral Ecology and Sociobiology 7: 287-291.

Plowright, R. C., and T. M. Laverty. 1984. The Ecology and Sociobiology of Bumble Bees. Annual Review of Entomology 29: 175-199.

Rao, S., and J. P. Strange. 2012. Bumble Bee (Hymenoptera: Apidae) Foraging Distance and Colony Density Associated With a Late-Season Mass Flowering Crop. Environmental Entomology 41: 905-915.

Rundlöf, M., G. K. S. Andersson, R. Bommarco, I. Fries, V. Hederstro, L. Herbertsson, O. Jonsson, B. K. Klatt, T. R. Pedersen, J. Yourstone, and H. G. Smith. 2015. Seed coating with a neonicotinoid insecticide negatively affects wild bees. Nature 521: 77-93.

Schweitzer, D. F., N. A. Capuano, B. E. Young, and S. R. Colla. 2012. Conservation and management of North American bumble bees. USDA, Forest Service, Washington, D.C. 17 p.

Tonietto, R. K., J. S. Ascher, and D. J. Larkin. 2017. Bee communities along a prairie restoration chronosequence: similar abundance and diversity, distinct composition. Ecological Applications 27: 705-717.

U.S. Fish and Wildlife Service. 2018. Conservation Management Guidelines for the Rusty Patched Bumble Bee (Bombus affinis). Version 1.6. Bloomington, MN. 16 p.

U.S. Fish and Wildlife Service (USFWS). 2018. Survey Protocols for the Rusty Patched Bumble Bee (Bombus affinis). Version 2.1. 29 p.

U.S. Fish and Wildlife Service (USFWS). 2016. Rusty Patched Bumble Bee (Bombus affinis) Species Status Assessment. Final Report, Version 1. Bloomington, MN. 100 p.

Williams, N. M., J. Regetz, and C. Kremen. 2012. Landscape-scale resources promote colony growth but not reproductive performance of bumble bees. Ecology 93: 1049-1058.

Wolf, S., and R. Moritz. 2008. Foraging distance in Bombus terrestris L. (Hymenoptera: Apidae). Apidologie 39: 419-427.

Wolf, S., T. Toev, R. Moritz, and R. Moritz. 2012. Spatial and temporal dynamics of the male effective population size in bumblebees (Hymenoptera: Apidae). Population Ecology 54: 115-124.

Wood, T. J., J. M. Holland, W. O. H. Hughes, and D. Goulson. 2015. Targeted agri-environment schemes significantly improve the population size of common farmland bumblebee species. Molecular Ecology 24: 1668-1680.

Xerces Society for Invertebrate Conservation. 2013. Petition to list the rusty patched bumble bee. 42.

Xerces Society for Invertebrate Conservation. 2017. Rusty Patched Bumble Bee Conservation Habitat Assessment Form and Guide. 12 p.

Appendix – Partial list of potential stressors and potential 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 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
		Direct contact/absorption	Contact mortality; Sub-lethal effects – e.g., reduced or no male production; egg infertility; reduced queen production	
	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
		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 exposure	Potential Response(s)	Reference(s)
Herbicides	Herbicide 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
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 spring foraging areas	Avoidance of area; deterioration in body condition and reduced reproductive output due to need to find appropriate nesting habitat elsewhere	
	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	
Soil Disturbance or Compaction	Direct disturbance		Immediate death or harm of individuals present in nests or overwintering sites (queens);	
	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	
	Construction matting or other temporary covering of soil surfaces	Temporary loss of potential nesting sites		
Competition for Resources from Commercial Honeybees	Reduced availability of nectar and pollen		Negative effects on the reproductive success; Nutritional stress that leads to increased susceptibility to pathogens	
	Disease transmission	See Pathogens and Parasites, above		