U.S. Fish and Wildlife Service

Draft Recovery Plan
for
Rusty Patched Bumble Bee (*Bombus affinis*)

Photo: Tamara Smith, USFWS

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DISCLAIMER

Recovery plans delineate reasonable actions that are believed necessary to recovery or protect the species. Plans are prepared by the U.S. Fish and Wildlife Service (Service), sometimes with the assistance of recovery teams, contractors, State agencies, Tribes, and others. Plans are reviewed by the public and subject to peer review before they are adopted by the Service. Criteria will only be obtained and funds expended contingent on appropriations, priorities, and other budgetary constraints. Recovery plans do not obligate other parties to undertake specific tasks. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in the plan formulation, other than the Service. They represent the official positions of the Service only after they have been signed by the Regional Director as approved. Approved recovery plans are subject to modifications as dictated by new findings, changes in species status, and the completion of recovery tasks. By approving this document, the Regional Director certifies that the information used in its development represents the best scientific and commercial data available at the time it was written.

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Draft Recovery Plan for Rusty Patched Bumble Bee (*Bombus affinis*)

This recovery plan describes criteria for determining when the rusty patched bumble bee should be considered for delisting as well as the actions necessary to meet those criteria and time and cost estimates for implementing recovery actions. An introduction provides a brief description of the species' habitat requirements, biology, and limiting factors. A more detailed accounting of the species biology, threats, and status is provided in the Species Status Assessment report (www.fws.gov/midwest/Endangered/insects/rpbb/). A Recovery Implementation Strategy describing the stepped-down activities to implement the recovery actions will be developed in coordination with recovery partners. The Recovery Implementation Strategy and Species Status Assessment are developed separately from the Recovery Plan and will be updated as needed. [Note: underlined words can be found in the glossary]

Introduction

Historically, the rusty patched bumble bee was broadly distributed across the eastern United States and Upper Midwest, from Maine in the U.S. and southern Quebec and Ontario in Canada, south to the northeast corner of Georgia, reaching west to the eastern edges of North and South Dakota (Figure 1; USFWS 2016, p. 49). Rusty patched bumble bee is a colonial species with an annual cycle that starts in early spring when colonies are initiated by solitary queens emerging from overwintering sites, progresses with the production of workers throughout the summer, and ends with the production of males and new queens in late summer and early fall. Survival and successful recruitment require floral resources (for food) from early spring through fall, undisturbed nest sites in proximity to foraging resources, and overwintering sites for the next year's queens. Populations consist of tens to hundreds of colonies, and the health (long-term productivity) of populations is affected by the quantity and quality (a diversity of floral resources) of nectar and pollen available and the proximity of these resources to nesting habitat. In addition to proximity, the degree to which the landscape is permeable to movement is important to ensure reproductive individuals are able to disperse to find unrelated mates (USFWS 2016, pp. 3, 15-17).

Prior to listing (in 2017), the species experienced a widespread and precipitous decline. The cause of the decline is unknown, but evidence suggests a synergistic interaction between an introduced pathogen and exposure to pesticides (specifically, insecticides and fungicides; USFWS 2016, p. 53). The remaining populations of rusty patched bumble bee are exposed to a number of interacting stressors, including pathogens, pesticides, habitat loss and degradation, managed bees, the effects of climate change, and small population biology (USFWS 2016, p. 40). These stressors likely operate independently and synergistically. For example, dietary stress due to insufficient floral resources may reduce an individual's resiliency to pathogens and pesticides, exposure to insecticides can reduce resistance to disease, and exposure to fungicides can increase insecticide toxicity (USFWS 2016, p. 53 and papers cited within). Although the limiting factors are multi-faceted, solutions may be simpler, as actions to reduce or remove any of these stressors are likely to have great benefits (Goulson et al. 2015, pp. 6-7).

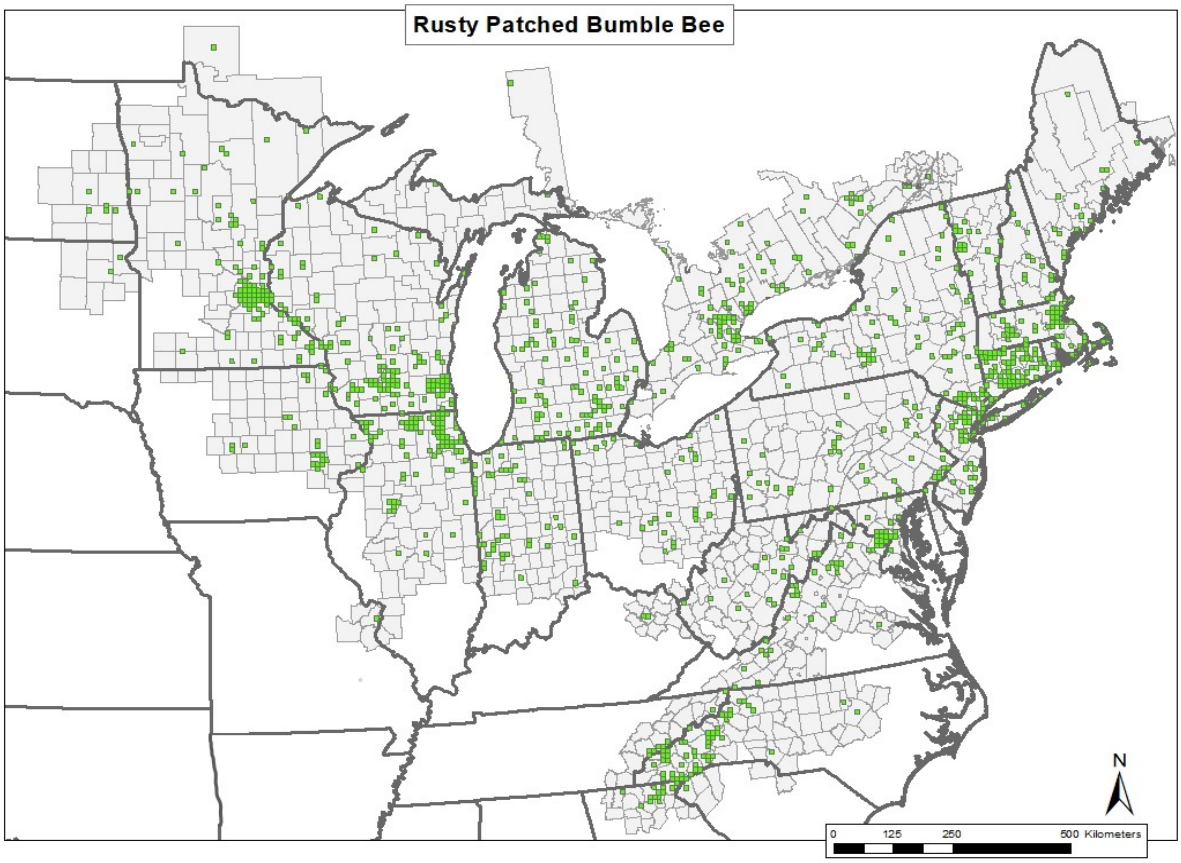

Figure 1: Historical distribution of rusty patched bumble bee. The historical county range is shaded in gray; documented populations (verified record of 1 or more individuals in a 10 x 10 km^2 grid since 1900) are shaded in green.

Recovery Vision and Strategy

The recovery vision for the rusty patched bumble bee is to conserve a sufficient number and distribution of populations to ensure the species' long-term viability such that it may be removed from the List of Endangered and Threatened Wildlife. To achieve long-term viability, the species' must endure the pressures of: 1) environmental stochasticity, 2) stressors, 3) catastrophes, and 4) novel changes in its environment, which requires multiple, healthy populations widely distributed across the breadth of adaptive diversity (USFWS 2016, pp. 20-21). Incorporating the conservation principles of representation, resiliency, and redundancy ensures sufficient number and distribution of populations such that the species can withstand these pressures.

Achieving the recovery vision requires a multi-pronged recovery strategy with spatial and temporal components. Spatially, the path to achieving recovery is structured by delineating units that ensure adaptive capacity is sufficient to allow for both near and long-term adaptation to novel changes in species' environment. The strategy also includes restoring redundancy and resiliency within these units to ensure the species can withstand natural annual variation, stressors, and catastrophes.

Temporally, the recovery strategy focuses on a sequence of first halting declines, then reversing declines, and ultimately securing the long-term viability of the species across a specified range. This phased approach involves emphasizing different objectives as recovery proceeds, thereby focusing initially on preventing extinction before moving toward broader, more proactive conservation objectives. The specific objectives include:

1. Preventing further loss of populations by (a) increasing the health of individuals and the number of colonies comprising populations, (b) improving the quality and quantity of habitat, and (c) ensuring appropriate connectivity between populations.
2. 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.
3. Buffering against novel changes in its physical and biological environment by restoring populations across the breadth of its natural adaptive diversity.
4. Ameliorating primary pervasive threats, including pathogens, pesticides, habitat loss, and effects of climate change (small population biology effects are ameliorated by accomplishing Objective 1).
5. Protecting populations and their habitats and abate threats into the foreseeable future.

This recovery plan identifies the principal uncertainties and assumptions underlying the initial stage of the rusty patched bumble bee recovery effort. Adaptive management, using the Recovery Implementation Strategy, is key to resolving uncertainties and erroneous assumptions and hypotheses. The key uncertainties include:

1. What is needed to maintain a healthy population? Specifically:
    a. The number of colonies needed to support a healthy population
    b. The physical requirements for nesting success and overwinter survival
    c. The foraging requirements of colonies
    d. The dispersal ecology of males and queens
    e. The minimum effective population size (Ne) and connectivity (gene flow) needed between populations to ensure population health
2. What is the distribution of populations needed to meet the recovery criteria?
3. What are the geographic-specific stressors affecting population health and to what extent are they preventing the full recovery of the rusty patched bumble bee?
4. Effects of climate change and how to mitigate for those effects into the future.

Lastly, involvement and support from partners and the public is integral to rusty patched bumble bee conservation. The cornerstone of this strategy is sustaining and expanding conservation partnerships and general public participation by implementing recovery through close collaboration and public outreach. This will help in shaping and coordinating short-term recovery efforts within the context of a cohesive, long-term approach.

Recovery Criteria

Recovery criteria provide objective, measurable thresholds used to indicate when the recovery objectives have been achieved. These criteria are founded on the most current scientific information available for the species and may require modification as the aforementioned uncertainties are resolved.

A. Downlisting Criteria

Criterion 1: A minimum of 159 populations distributed across five Conservation Units (Figure 2), as specified in Table 1.

A minimum number of populations are documented in each Conservation Unit as specified in Table 1. A population is documented by the detection of at least one individual in 3 of the last 5 years (within a 10 x 10 km^2 grid as defined in USFWS 2016, p. 11).

Rationale: Criterion 1 is needed to preserve the breadth of genetic and ecological diversity, thereby maintaining the species' ability to adapt to a changing environment. Conservation Units were delineated to capture the variation in adaptive diversity across the rusty patched bumble bee's range (Figure 2). The units were delineated by overlaying Bailey's Ecoregion Divisions (Bailey 1983, 1994) (to capture differences in ecological communities) with five degree longitudinal and latitudinal lines (to capture temperature variation), and then slightly modified to incorporate physical barriers to dispersal (for example, Lake Michigan) and state boundaries for ease of Recovery Implementation Strategy planning and implementation. Lastly, the Bailey's Ecoregion Divisions in the Appalachian Mountains (Hot Continental Mountains) and Piedmont areas (Subtropical Division) were combined because the species was not historically common and consistently found throughout the Piedmont region (Subtropical Division) in Southeastern United States.

Criterion 1 also prescribes the number of populations needed in each Conservation Unit. The natural history of rusty patched bumble bee entails being abundant and widely distributed (1385 populations documented across 29 states and 2 Canadian provinces; USFWS 2016, p. 29, USFWS 2019 unpublished database). While it is not necessary to restore every historical occurrence, recovery needs to resemble its natural abundance and distribution to ensure long-term persistence. Although the number of populations (159) represents only 12% of the historical populations, documenting these populations likely indicates many more populations exist because detecting rusty patched bumble bee at a site can be difficult (for example, a study in Minnesota found a 30% probability of detection if present; Evans et al. 2019, pp. 13-14). Thus, the number and distribution of populations specified in Table 1, in combination with criteria 2 and 3 below, demonstrate persistence of multiple, widely distributed healthy populations within each Conservation Unit. This should enable the species to withstand environmental stochasticity, stressors, catastrophes, and novel changes in its environment, thereby achieving viability.

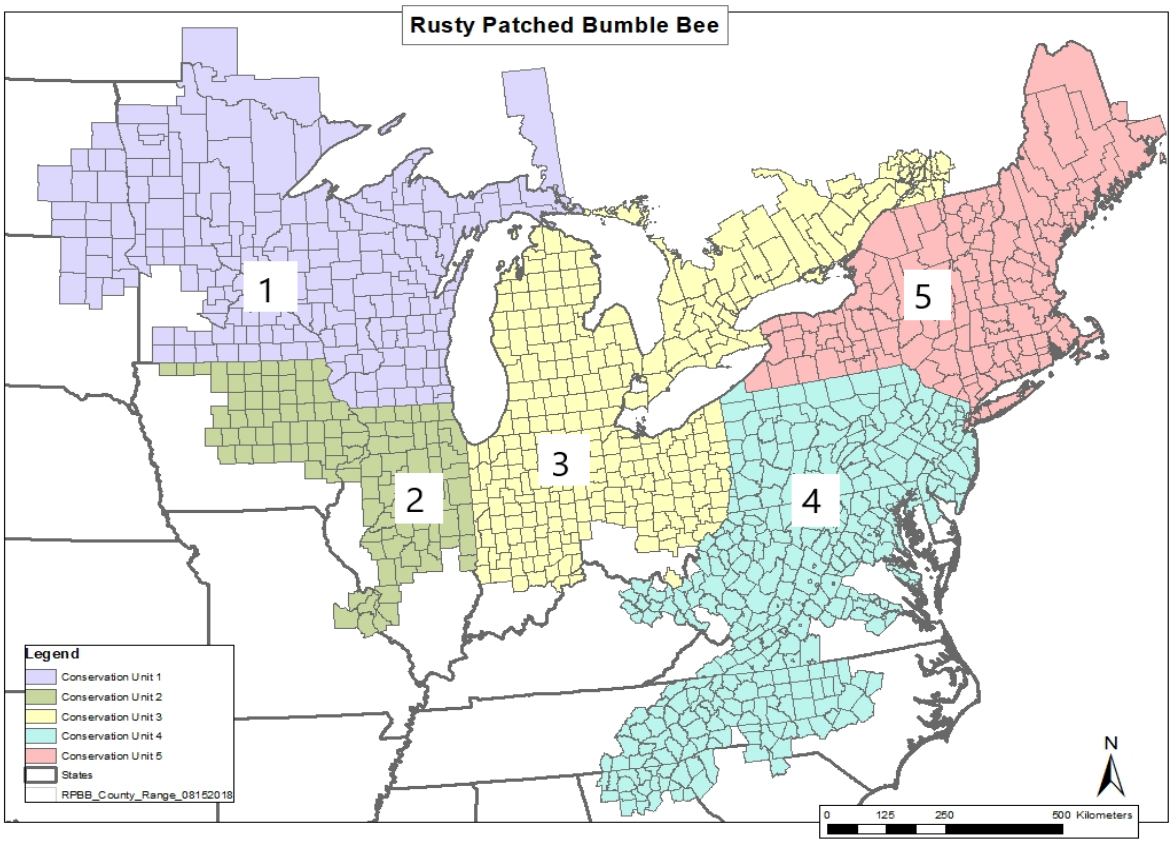

Figure 2: Rusty patched bumble bee Conservation Units (CUs) from west to east: CU1 (Upper West), CU2 (Lower West), CU3 (Midwest), CU4 (Southeast), and CU5 (Northeast).

Table 1. Rusty patched bumble bee Conservation Units, total number of historically occupied populations per Conservation Unit, minimum number of populations per Conservation Unit (CU) (Downlisting Criterion 1)[1], and the minimum number of healthy populations per Conservation Unit (Downlisting Criterion 2).[2]

Conservation Unit	Number of historically occupied populations per CU	Minimum number of populations per CU (Criterion 1)	Minimum number of healthy populations per CU (Criterion 2)
CU1: Upper West	274	32	16
CU2: Lower West	125	14	7
CU3: Midwest	347	40	20
CU4: Southeast	250	29	14
CU5: Northeast	389	45	22
Total	**1,385**	**159**	**80**

[1] The minimum number of populations was calculated by multiplying the historical number of populations per unit by half of the average decadal occupancy (decadal average =23%, USFWS 2016, p. 29 Table 3.2).
[2] The minimum number of healthy populations (Criterion 2) is half of the minimum number of populations per Conservation Unit (Criterion 1).

Criterion 2: A minimum number of healthy populations within each Conservation Unit, as specified in Table 1.

For recovery purposes, a healthy population will be demonstrated by:

2.1 Consistent detection of at least 5 distinct colonies over the most recent 10 years. Individual colonies may be identified through genetic analyses or by using the number of individuals detected (if proven, through research, to be a reliable method). All 5 colonies do not need to be detected in each of the 10 years but must be detected in multiple years.
2.2 Evidence of genetic health over the most recent 10 years. Genetic health must be demonstrated by at least two genetic metrics (for example, effective population size, heterozygosity, and allelic richness).
2.3 Pathogen and pesticide loads are below levels that could cause meaningful loss of reproductive capacity of the population.
2.4 A high level of certainty—demonstrated via a rigorous analysis—that the population will persist given stressors and environmental variation.

Rationale: Criterion 2 is needed to ensure populations are successfully recruiting over time (healthy). Assessing health of the 159 populations, however, is infeasible. Demonstrating that half of the minimum number of documented populations are healthy balances the desire to know the actual number of healthy populations with the effort and feasibility to do so. Although a healthy population is composed of tens to hundreds of colonies (USFWS 2016, p. 17), consistent detection of five colonies (given a low probability of detection) coupled with Subcriteria 2.2 - 2.4 gives reasonable assurance of a healthy population. The methods to measure and assess population health will be refined throughout the Recovery Implementation Strategy process to conform to the best available data.

Criterion 3: Population clusters are distributed across a diversity of habitat types, aspects, slopes, elevations, and latitudes within each Conservation Unit.

In achieving Criterion 3, a population cluster is two or more healthy populations that are adjacent to each other.

Rationale: Population clusters are needed within each Conservation Unit to foster gene flow between populations, which in turn, facilitates demographic rescue and ensures genetic health and adaptability of populations. In re-establishing[3] gene flow between populations, it is also important to ensure adverse genetic impacts (for example, due to gene swamping and outbreeding depression) are unlikely to occur. Thus, the geographic location and number of re-established population clusters will be determined through the Recovery Implementation Strategy process and, if using reintroductions, captive propagation and reintroduction plans will be developed per Service policy (65 FR 56916; September 20, 2000). Additionally, population clusters widely distributed across a diversity of climatological regions and habitats are needed to guard against effects from catastrophic events (for example, broad-scale heat waves and droughts), regional-scale environmental stochasticity, disease epidemics, and climate change.

[3] Re-establishing gene flow could be achieved through various methods, such as natural movement from other sites, augmentation, or reintroduction.

B. Delisting Criteria

Criterion 1: Downlisting criteria 1, 2, and 3 have been met.

Criterion 2: Mechanisms are in place that provide a high level of certainty that downlisting criteria will continue to be met into the foreseeable future.

In achieving delisting Criterion 2, Conservation Unit-specific mechanisms should ensure:

2.1 Population abundance, numbers, and distribution will be maintained at the levels required to meet downlisting criteria,
2.2 Sufficient quality and quantity of suitable habitat will be maintained, and
2.3 The negative effects of the primary threats (including but not limited to pathogens, pesticides, climate change, and managed bees) will be managed.

Rationale: Mechanisms are needed to ensure the downlisting criteria will continue to be met into the foreseeable future. Examples of mechanisms include agreements, regulations, plans, conservation easements, and land acquisition. For example, developing and implementing species-specific management plans and best management practices can be used to demonstrate that a sufficient quality and quantity of habitat will be maintained into the foreseeable future. Similarly, implementing species-specific integrated pest management programs (to manage adverse effects of pesticides), implementing disease epidemic prevention plans (to reduce disease introduction and spread), and participating in clean stock programs (to manage adverse effects from commercially-managed bees) may be used to ensure threats will be managed into the foreseeable future. Conservation unit-specific mechanisms will be developed through the Recovery Implementation Strategy process.

Uncertainties: As described under the Recovery Strategy section, the above criteria rely upon several key assumptions. Resolving these key uncertainties is needed to provide high confidence that the criteria ensure the rusty patched bumble bee has sufficient ability to adapt to novel changes in its environment, is able to withstand catastrophic events, and is resilient to annual environmental variation and stressors.

Recovery Actions

This section describes the broad categories of the actions necessary to achieve the recovery vision for the rusty patched bumble bee. These actions apply to each of the conservation units, but specific implementation may differ geographically (population-specific). These broad categories of actions will be used to develop step-down, recovery implementation strategies and prioritized tasks specific to each Conservation Unit's needs. Additionally, some actions will be developed and coordinated across Conservation Units as they apply rangewide (for example, research needs, outreach and education). The recovery implementation strategies will be developed in coordination with our conservation partners and updated on an as-needed basis.

The broad categories of actions include:

1. **Minimize risks due to pathogens**: Successful minimization measures may include: conducting population-specific threats analyses, implementing and enforcing clean stock programs, implementing good practices for production and use of commercial bees (for example, monitoring pathogens in bee stocks and preventing bee escapes), conducting research, and providing education and outreach to the public and commercial bee keepers. Estimated cost: $1,200,000.
2. **Minimize exposure to harmful pesticides**: Successful minimization measures may include: creating pesticide registry programs, executing pollinator-safe labeling on nursery plants, establishing buffers around populations (for example, habitat restoration or land acquisition), implementing integrated pest management, conducting research, and providing education and outreach to the public and agricultural community. Estimated cost: $855,000 (+ undetermined cost for potential land acquisition).
3. **Manage and protect habitat**: Successful management and protection measures may include: maintaining, improving, and restoring overwintering, foraging, and nesting habitat; restoring connectivity for dispersal; developing and implementing habitat management plans; creating habitat management incentive programs; conducting research; and providing education and outreach to the public and land managers; and securing permanent protection of habitat through land acquisition and/or conservation easements by land management agencies and nongovernmental organizations. Estimated cost: $2,692,000.
4. **Manage and protect populations:** Successful management and protection measures may include: increasing the number and distribution of populations and improving the health of target populations by increasing effective population sizes, implementing conservation propagation methods (such as augmentation/enhancement, reintroduction, insurance populations, and translocation), and conducting research (for example, demographics, nesting and overwintering ecology, genetics, dispersal behavior, and effects of climate change). Estimated cost: $1,335,000.
5. **Assess population status (monitoring) and conduct surveys**: This may include: developing and using rigorous standardized protocols and community science to monitor population health, habitat, and threats; conducting surveys at potential new sites; and sharing data among partners. Estimated cost: $7,129,000.
6. **Ensure effective planning and coordination**: This may include: integrating planning and coordination among recovery partners, implementing and reviewing Recovery Implementation Strategies, tracking recovery implementation progress and success, and implementing adaptive management. Estimated cost: $200,000.

Date of Recovery: If all actions are fully funded and implemented as outlined, including full cooperation of partners needed to achieve recovery, we anticipate delisting could be achieved as soon as 2059.

Estimated Cost of Delisting: The estimated costs associated with implementing recovery actions for delisting are $13,411,000. Cost estimates reflect costs for species actions needed to achieve rusty patched bumble bee recovery. Some cost for recovery actions are not determinable at this time, therefore the total cost for recovery may be higher than this estimate.

Glossary

Adaptive diversity – The range of variation within a species, and the source of species' adaptive capabilities. For rusty patched bumble bee, its adaptive diversity is a function of the amount and spatial distribution of genetic and phenotypic diversity (USFWS 2016, pp. 20-21). By maintaining these two sources of adaptive diversity, rusty patched bumble responsiveness and adaptability is preserved.

Allelic richness – The number of alleles present at a locus.

Colony – A colony consists of a single queen, female workers and males. Colony sizes of rusty patched bumble bee are considered large compared to other bumble bees, and healthy colonies may consist of up to 1000 individual workers in a season (Macfarlane et al. 1994, pp. 3-4).

Gene swamping – Loss of the genetic variance at a locus under selection because gene flow is too high (Lenormand 2002).

He (Heterozygosity) - The proportion of individuals heterozygous at a locus.

Healthy population – A population that is able to successfully recruit (produce queens) over time. To successfully recruit, a population needs to be demographically, genetically, and physically healthy (USFWS 2016, pp. 18-20).

Demographic health – 10s to 100s of colonies and population growth rate (lambda, λ) >1

Genetic health – large effective population size (Ne), high heterozygosity (He) and allelic richness, and sufficient gene flow between populations (to maintain He and allelic richness).

Physical health – good body condition.

Insurance population – A healthy functioning population managed in captivity to maintain genetic diversity in case of catastrophic loss in the wild.

Ne – Effective population size. The number of mated gynes (reproductive females).

Outbreeding depression – Reduced fitness of offspring from mating between genetically divergent individuals (Whiteley et al. 2015).

Population – A population is a collection of tens to hundreds of colonies, and the health (long-term productivity) of populations is affected by the quantity and quality (a diversity of floral resources) of nectar and pollen available and the proximity of these resources to nesting sites. For monitoring the number of populations over time, a population is a single 10 x 10 kilometer (km) grid. Population grids were delineated by overlaying 10 x 10 km grids across the range of rusty patched bumble bee and assigning a unique numerical identifier to each 10 x 10 km grid (for further explanation see USFWS 2016, p. 11).

Population cluster – Two or more adjacent populations (abutting 10 x 10 km grids).

Redundancy – An indicator of the ability of a species to withstand catastrophic events by spreading risk among multiple populations or across a large area (Smith et al. 2018, p. 304).

Representation – An indicator of the ability of a species to adapt to changing environment conditions over time as characterized by the breadth of genetic and environmental diversity within and among populations (Smith et al. 2018, p. 304).

Reproductive capacity – The average number, size, and composition (number of workers, gynes, and males produced) of the colonies comprising a population.

Resiliency – An indicator of the ability of a species to withstand stochastic disturbance; resiliency is positively related to population size and growth rate and may be influenced by connectivity among populations (Smith et al. 2018, p. 304).

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