# Habitat Connectivity Model
## *for the*
## Rusty Patched Bumble Bee (*Bombus affinis*)

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**Minnesota-Wisconsin Field Office**
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The Minnesota/Wisconsin FWS Field Office has adapted a habitat connectivity model that considers the likelihood of *Bombus affinis* movement based on the most recent National Land Cover Database maps. This model allows us to assess the likelihood of bumble bee movement away from the locations of known records based on the manner in which various land uses and conditions may affect those movements. Land classes are grouped as having strong, moderate, weak or no limits on *B. affinis* movement based on the best available information for this species or similar *Bombus* species. This methodology was derived from based on a similar model created to examine movement of *B. vosnesenskii* (*i.e.*, Jha and Kremen 2013, entire). The polygons generated from the *B. affinis* habitat connectivity model suggest areas with the highest potential for the species to be present based on typical bumble bee foraging distances and likelihood of suitable habitat.

The model produces a series of irregular rings or strata around each record that represent successively decreasing likelihoods of movement by a bumble bee away from the point of observation. We have adapted the innermost 'ring' around each *B. affinis* record, dated 2007-present, to produce polygons that describe the area where there is highest potential for the species to occur (*i.e.*, **High Potential Zones**). Due to the variations in land condition around each record, the **High Potential Zones** range an average of(about 2.5 miles (4 km) from observation points and together comprises only about 0.1% of the species' historical range (see map at https://www.fws.gov/midwest/Endangered/insects/rpbb/rpbbmap.html). These zones although not of uniform size, have discrete boundaries that will be used by FWS field offices and served online via the FWS Information for Planning and Conservation website (IPaC, https://ecos.fws.gov/ipac/) to assist action agencies determine whether their actions are likely to may overlap with current species occurrences.

As a balance between typical foraging distances and potential dispersal movements, high potential zones provide a reasonable basis for describing where the species is likely to be present and where federal agencies should cooperate with the FWS to evaluate the potential effects of their actions. Studies of other bumble bee species typically exhibit foraging distances of less than 0.6 mile (1 km) from their nesting sites (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 typical foraging distances, however, we should also consider movements that rusty patched bumble bees may make to establish new home ranges through dispersal. Based on studies of a closely related species, *B. terrestris*, the maximum dispersal distance of the rusty patched bumble bee is likely about 0.6 to 6 miles (1-10 km, Kraus et al. 2009, p. 249; Lepais et al. 2010, pp. 826-827).

Similar to the process used to model the **High Potential Zones**, the model produces a series of irregular rings or strata around likely dispersal zones for each record that represent successively decreasing likelihoods of movement by a bumble bee away from the point of observation based on land classifications. **Extant** site records (2007-present) are used as a starting point for movement across weighted land classifications to develop a 'heat map' that describes areas of decreasing likelihood of travel from the observation point. We then use the maximum dispersal distance of 6.2 mi (10 km) as a guide to further refine the probability of species occurrence and to identify what we refer to here as **Primary Dispersal Zone** (https://www.fws.gov/midwest/Endangered/insects/rpbb/rpbbmap.html and close-up example, Fig.1).

We have adapted the first four 'rings' around each *B. affinis* record, dated 2007-present, to produce polygons that describe the area where there is a reasonable potential for the species to be present (*i.e.*, **Primary Dispersal Zones**). We have also modeled additional areas around slightly older records (*i.e.*, 2000-2006 records, Uncertain Sites) that have not had sufficient follow up surveys; these areas are called Uncertain Zones.

Due to the variations in land condition around each record, the **Primary Dispersal Zones and Uncertain Zones** range from about 2.5 to 10 mi (about 4 to 16 km) from observation points (Fig. 1). These zones although not of uniform size, have discrete boundaries that will be used by FWS field offices and served online via the FWS website (http://www.fws.gov/midwest/endangered/insects/rpbb/guidance.html) to surveyors in determining where non-lethal surveys are recommended and where a scientific recovery permit for surveys might be recommended. Surveyors can download the latest available ESRI ArcMap shapefile from the above website. Updates are anticipated to occur quarterly (*e.g.*, updates are currently scheduled for February 15, May 15, August 15, and November 15th) of each year to make sure the most up to date habitat and survey information is being utilized.

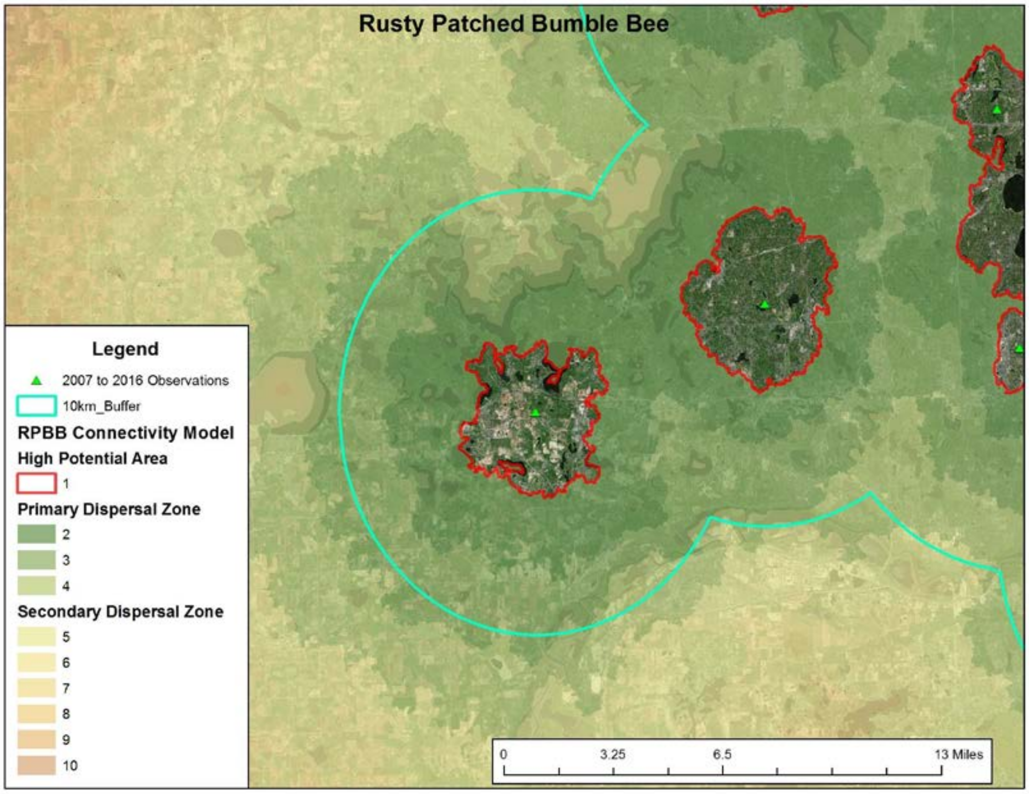


**Figure 1.** An example of **High Potential Zones** (outlined in red) and the **Primary Dispersal Zones** (shades of green) for *B. affinis*, based on the habitat model described above and on species survey data compiled through 2016 (U.S. Fish and Wildlife Service Rusty Patched Bumble Bee Unpublished Geodatabase). The shaded connectivity model highlights additional conservation areas with potential to connect existing populations; the areas with the highest potential for connectivity/suitable habitat are shown in shades of green (Primary Dispersal Zones) and the least suitable areas shown in shades of brown and red.

## Literature Cited

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