High Potential Zone Model

for the

Rusty Patched Bumble Bee (*Bombus affinis*)

U.S. Fish and Wildlife Service Minnesota-Wisconsin Field Office

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The Minnesota-Wisconsin U.S. Fish and Wildlife (USFWS) Ecological Services Field Office developed a High Potential Zone (HPZ) model using ArcGIS software that considers the likelihood of rusty patched bumble bee (*Bombus affinis*) movement based on the National Land Cover Database (NLCD, https://www.usgs.gov/centers/eros/science/national-land-cover-database). This model allows us to assess the likelihood of bumble bee distribution from the locations of known records based on the manner in which various land cover types may affect bumble bee movement and behavior. Land cover types 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 bumble bee (*Bombus*) species. This methodology was based on a similar model created to examine movement of the yellow-faced bumble bee (*B. vosnesenskii*) (*i.e.*, Jha and Kremen 2013, entire). The polygons generated from the *B. affinis* HPZ model suggest areas with the highest potential for the species to be present based on typical bumble bee foraging distances, estimated dispersal distances, and ability of bumble bees to move through various land cover types. This model does not attempt to identify or quantify suitable *B. affinis* habitat.

The HPZ 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, HPZ). Due to the variations in land condition around each record, observation points average about 0.9 miles (1.5 km) to the closest vertex of the corresponding HPZ and together comprises only about 0.7% of the species' historical range (based on data as of April 29, 2022; see map at https://www.arcgis.com/home/webmap/viewer.html?webmap=2716d871f88042a2a56b8001a1flacae&extent=-100.6667%2c29.7389%2c-48.8551%2c50.9676). The HPZs, although not of uniform size, have discrete boundaries that will be used by USFWS field offices and served online via the USFWS Information for Planning and Conservation website (IPaC, https://ecos.fws.gov/ipac/) to assist action agencies determine whether their actions may overlap with current species occurrences.

As a balance between typical foraging distances and potential dispersal movements, HPZs provide a reasonable basis for describing where the species is likely to be present and where federal agencies should cooperate with the USFWS 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 *B. affinis* may make to establish new home ranges through dispersal. Based on studies of a closely related species, buff-tailed bumble bee (*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 HPZs, the model also 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 Zones (https://www.arcgis.com/home/webmap/viewer.html?webmap=2716d871f88042a2a56b8001a1f1acae&extent=-100.6667%2c29.7389%2c-48.8551%2c50.9676 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 or PDZs). 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 to confidently verify the species absence; these areas are called Uncertainty Zones.

Due to the variations in land condition around each record, the closest vertex of PDZs and Uncertainty Zones averages about 8.2 mi (13.2 km) from observation points (Fig. 1, using data as of April 29, 2021). These zones, although not of uniform size, have discrete boundaries that will be used by USFWS field offices and served online via the USFWS website (https://www.arcgis.com/apps/mapviewer/index.html?webmap=2716d871f88042a2a56b8001a1f1acae) to surveyors in determining where non-lethal surveys are recommended and where a scientific recovery permit for surveys might be recommended. Surveyors can access the latest available ESRI

ArcMap shapefile from the above website. Updates are anticipated to occur annually (*e.g.*, updates are currently scheduled for mid-March, but may be updated again in late spring to correct errors) to make sure the most up to date NLCD and survey information is being utilized.

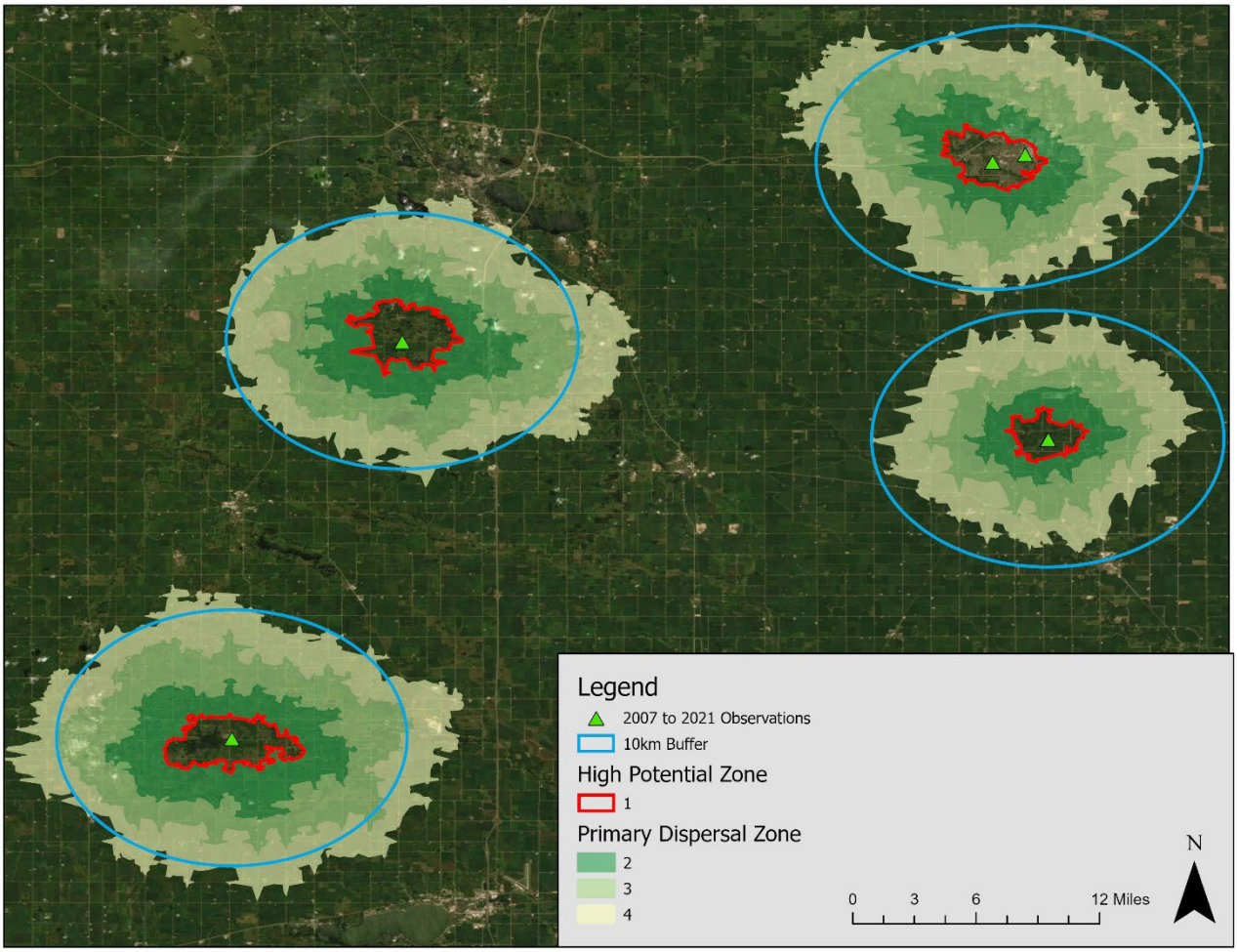

Figure 1. An example of **High Potential Zones** (outlined in red) and the **Primary Dispersal Zones** (shades of green) for *B. affinis*, based on the HPZ model described above and species survey data compiled through April 29, 2021 (U.S. Fish and Wildlife Service Rusty Patched Bumble Bee Unpublished Geodatabase).

Literature Cited

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

Jha, S., and C. Kremen. 2013. Urban land use limits regional bumble bee gene flow. Molecular Ecology 22:2483–2495.

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

Kraus, F.B., S. Wolf, and R.F. A. Mortiz. 2009. Male flight distance and population substructure in the bumble bee *Bombus terrestris*. 78:247-252.

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

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.

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(4):905-915.

Wolf, S. and R.F.A. Moritz. 2008. Foraging distance in *Bombus terrestris* (Hymenoptera: Apidae). Apidologie 38:419-427.