

A Petition to list the Yellow Banded Bumble Bee (*Bombus terricola*) as an Endangered, or Alternatively as a Threatened, Species Pursuant to the Endangered Species Act and for the Designation of Critical Habitat for this Species



Photo by Leif Richardson from the U.S. Department of Agriculture “Bumble Bees of the Eastern United States”

Submitted to the United States Secretary of the Interior acting through the United States Fish and Wildlife Service

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I. EXECUTIVE SUMMARY

The Yellow-banded bumble bee (*Bombus terricola*) is in danger of extinction. *B. terricola* was historically very common in the Northeast and Midwestern United States as well as most of Canada (Cameron, *et al.*, 2011 at 663-64). However, recent studies show a drastic reduction in the range and relative abundance of this species (Colla & Packer, 2008 at 1387; Cameron, *et al.*, 2011 at 664; Bushmann, 2012 at 9; Grixti, *et al.*, 2009 at 79). For example, in one survey conducted in Ontario, Canada between 1971 and 1973, researchers found 119 *B. terricola* (Colla & Packer, 2008 at 1384). In a survey conducted using the same survey sites between 2004 and 2006, researchers found only a single *B. terricola* (Colla & Packer, 2008 at 1385). In an extensive nationwide survey conducted between 2007 and 2009, researchers found only 31 *B. terricola* in over 382 sampling sites throughout the United States (Cameron, *et al.*, 2011 at 662). As discussed throughout this petition, several additional studies suggest *B. terricola* is in drastic decline throughout all of its range.

There are numerous threats to the continued existence of *B. terricola*. The major threats include diseases introduced by commercially reared bumble bees (Colla, *et al.*, 2006 at 462) and the use of pesticides (Evans, *et al.*, 2008 at 29). In addition, *B. terricola* faces other threats including habitat destruction (Öckinger & Smith, 2007 at 56), degradation, fragmentation, and loss (Hines & Hendrix, 2005 at 1481; Kimoto, 2012b at 12–13; Ahrné, *et al.*, 2009 at 4), changes in population dynamics (Whitehorn, *et al.*, 2009 at 2, 5–6), and climate change (*see* Memmott, *et al.*, 2007 at 6).

Defenders of Wildlife (Defenders) requests that the U.S. Secretary of the Interior, acting through the U.S. Fish and Wildlife Service (Service), list the Yellow-banded bumble bee (*Bombus terricola*) as an endangered, or alternatively as a threatened, species under the Endangered Species Act (ESA), 16 U.S.C. §§ 1531-1544, and concurrently designate critical habitat for this species as required by the ESA, 16 U.S.C. § 1533(b)(6)(C). Defenders submits this petition pursuant to the ESA, 16 U.S.C. § 1533(b)(3)(A), and the Administrative Procedure Act (APA), 5 U.S.C. § 555(e).

II. ENDANGERED SPECIES ACT AND IMPLEMENTING REGULATIONS

In 1973, Congress enacted the Endangered Species Act to conserve the ecosystems upon which endangered and threatened species depend, and to provide a program for the conservation of such species. 16 U.S.C. § 1531(b). These ESA protections apply only to species that have been listed as endangered or threatened under the provisions of the Act.” 16 U.S.C. § 1532(6). The ESA defines an endangered species as one that is “in danger of extinction throughout all or a significant portion of its range. . .” 16 U.S.C. § 1532(6). A “threatened species” is one that “is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.” 16 U.S.C. § 1532(20). The Service must consider the following five listing factors set forth in 16 U.S.C. § 1533(a)(1) in evaluating whether a species is threatened or endangered:

- A. The present or threatened destruction, modification, or curtailment of its habitat or range;
- B. Overutilization for commercial, recreational, scientific, or educational purposes;
- C. Disease or predation;
- D. The inadequacy of existing regulatory mechanisms; or
- E. Other natural or manmade factors affecting its continued existence.

A species must only be imperiled by any one, or any combination of, the above listing factors to qualify for federal listing as an endangered or threatened species. 50 C.F.R. § 424.11.

The Service is required to make a listing determination “solely on the basis of the best scientific and commercial data available to [it] after conducting a review of the status of the species and after taking into account” existing efforts to protect the species. 16 U.S.C. § 1533(b)(1)(A); *see also* 50 C.F.R. §§ 424.11(b), (f).

Upon receipt of a listing petition, the Service is required to determine “whether the petition presents substantial scientific or commercial information indicating that the petitioned action may be warranted” within 90-days. 16 U.S.C. § 1533(b)(3)(A). For purposes of the 90-day finding, the ESA defines “substantial information” as “that amount of information that would lead a reasonable person to believe that the measure proposed in the petition may be warranted.” 50 C.F.R. § 424.14(b)(1). If the Service concludes that the listing of a species may be warranted, the Service has twelve months, from the date the petition was received, to institute a status review and determine whether the species will be listed. 16 U.S.C. § 1533(b)(3)(B). If the Service determines that protections are not warranted, the listing process ends, and the ESA authorizes judicial review of either a negative 90-day finding or a negative 12-month finding. *Id.* § 1533(b)(3)(C)(ii).

III. TAXONOMIC STATUS

All bumble bees belong to the genus *Bombus* within the family *Apidae*. The Yellow-banded bumble bee (*Bombus terricola*) is part of the subgenus *Bombus sensu stricto*. *Bombus sensu stricto* (in the strict sense) has been identified as a valid subgenus of *Bombus* by Dr. Paul Williams (Williams, *et al.*, 2008 at 53; Natural History Museum, 2014; ITIS Report, 2014). *B. terricola* was first described and validated as a species by Kirby in 1837 (ITIS Report, 2014).

Kingdom	<i>Animalia</i>
Phylum	<i>Arthropoda</i>
Subphylum	<i>Hexapoda</i>
Class	<i>Insecta</i>
Subclass	<i>Pterygota</i>
Order	<i>Hymenoptera</i>
Family	<i>Apidae</i>
Genus	<i>Bombus</i>
Species	<i>Terricola</i>

Table 1. Taxonomic table of *Bombus terricola* (ITIS Report, 2014).²

B. terricola is recognized as a valid species under the Integrated Taxonomic Information System (ITIS) (ITIS Report, 2014). While there has been debate about whether *B. terricola* is conspecific with *Bombus occidentalis*, recently *B. terricola* has been identified as being genetically divergent from *B. occidentalis*, confirming its status as a distinct species (Cameron, *et al.*, 2007 at 180; Williams, *et al.*, 2012 at 39; NatureServe Explorer, 2015 at 1; Owen & Whidden, 2013 at 285). Drs. Robin Owen and Troy Whidden demonstrated that the two species (*B. terricola* and *B. occidentalis*) “can be distinguished by wing morphometrics as well as RAPD genotypes,” and that color pattern variation is present only in *B. occidentalis* (Owen & Whidden, 2013 at 285). Dr. Paul Williams has also concluded that *B. occidentalis* and *B. terricola* should be acknowledged as distinct species (Williams, *et al.*, 2012 at 19).

²http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=714843 (last visited Dec. 19, 2014).

IV. SPECIES DESCRIPTION

A. Queens and Workers

B. terricola queens are 17-19 millimeters in length and have an abdomen that is 9-10 millimeters in width. While the head is entirely black, the second and third segments of the abdomen as well as the front of the thorax are all yellow (Mitchell, 1962 at 519). Queens have a distinct fringe of brownish-yellow hair on the fifth segment of the abdomen. *B. terricola* workers are similar in appearance to the queens, but are smaller in size. Workers are 9-14 millimeters in length with an abdomen 5-7 millimeters in width (Mitchell, 1962 at 519).

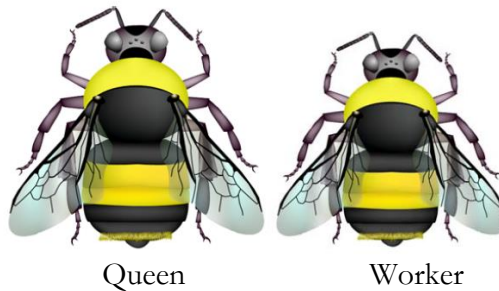


Figure 1. Illustration of *B. terricola* queen and worker (Evans, 2008).

B. Males

Males are 13-17 millimeters in length with an abdomen that is 6-8 millimeters in width (Mitchell, 1962 at 519). Males have long yellow hair on top of the head and on the face. Like the females, males have similar bands of yellow on the second and third segment of the abdomen as well as on the thorax. Male *B. terricola* also have a fringe of black-yellow hair on the fifth segment of the abdomen (Mitchell, 1962 at 519).



Figure 2. Illustration of *B. terricola* male (Evans, 2008).

V. BIOLOGY, HABITAT REQUIREMENTS AND POLLINATION ECOLOGY

A. Biology & Habitat Requirements

Bumble bee colonies are annual (Mitchell, 1962 at 514). Queens emerge from winter hibernation and establish a colony each spring, usually in an abandoned rodent or birds nest (Thorp, *et al.*, 1983 at 1). The queen forages on floral resources and relies on provisions of pollen she has collected in the early spring to provide protein to her developing eggs that were fertilized the previous fall (Spivak, *et al.*, 2011 at 35). Queens continue to produce offspring, including new queens, throughout the year, who then mate and subsequently hibernate, to start the cycle anew the following spring (Thorp, *et al.*, 1983 at 2). Workers generally collect food, defend the colony and care for young while the queen continues to lay eggs (Thorp, *et al.*, 1983 at 2)

The flight season of *B. terricola* is between April and October in the east (Mitchell, 1962 at 520). During this time, bumble bees such as *B. terricola* require a continuous supply of floral resources (Goulson, 2008 at 193). Bumble bees benefit in terms of species richness and abundance when there is a high abundance of nectar and pollen resources and a continuous availability of nectar throughout the season (Öckinger & Smith, 2007 at 51). Bumble bees also benefit from landscapes offering meadow complexes with a variety of habitats and continuous availability of floral resources throughout the year (Hatfield & Lebuhn, 2007 at 156). In particular, the availability of floral resources late in the season may affect species fitness because this is the time in the season that bumble bee communities produce reproductive bees (Hatfield & Lebuhn, 2007 at 157). Additionally, bumble bee populations may be negatively affected when nest sites, nectar, and pollen sources are too isolated from one another (Öckinger & Smith, 2007 at 51).

B. Pollination Ecology

Bumble bees are important vectors for transporting pollen between flowers, aiding seed and fruit production. *B. terricola* collects pollen by sonication or buzz pollination, which vibrates the anthers of certain flowers, releasing pollen (Batra, 1993 at 252). Many plant species, such as male-fertile potato flowers, rely on sonication to reproduce. In the Northern Adirondacks it was shown that even though there were seven other bumble bee species in the area, none but *B. terricola* pollinated the potatoes (Batra, 1993 at 253). Lowbush blueberries are another plant that is frequently and efficiently pollinated by sonication (Javorek, *et al.*, 2002 at 349). Bumble bees are among the most important depositors of lowbush blueberry pollen (Javorek, *et al.*, 2002 at 349) in Eastern Maine, and parts of maritime Canada (Bushmann, 2012 at 1). Likewise, bumble bees are the most important pollinators of cranberries, which produce higher yields, more seeds per berry and larger fruit when pollinated by bumble bees (Ortwine-Boes & Silbernagel, 2003 at 1). *B. terricola* is also one of the most important pollinators of alfalfa crops in Northern Wisconsin. (Fye & Medler, 1954 at 81).

B. terricola is a generalist forager and has been seen foraging on many other types of plants including: *Leontodon autumnale*, *Daucus carota*, *Potentilla recta*, (Heinrich, 1976 at 111); *Asclepias syriaca* (milkweed), *Solanum dulcamara* (bittersweet), *Spiraea latifolia* (Heinrich(2), 1976

at 877); *Solidago Canadensis* (goldenrod), *Epilobium angustifolium* (fireweed) *Impatiens bijflora* (jewelweed) (Heinrich, 1971 at 49-50); *Salix* sp. (Heinrich(2), 1976 at 876, 877), *Chamoedaphne calyculata* (Heinrich(2), 1976 at 877), *Prunus pennsylvanica* (Heinrich(2), 1976 at 877), *Rhodora Canadensis* (Heinrich(2), 1976 at 877), *Vaccinium* sp. (Heinrich(2), 1976 at 877), *Rubus strigosus* (Heinrich(2), 1976 at 877), *Hieracium* sp. (Heinrich(2), 1976 at 877), *Cephalanthus occidentalis* (Heinrich(2), 1976 at 877), *Solidago Canadensis* (Heinrich(2), 1976 at 877), *Solidago rugosa* (Heinrich(2), 1976 at 877), *Solidago odora* (Heinrich(2), 1976 at 877), *Trifolium repense*, *Melilotus* sp., *Medicago sativa*, *Linus* sp., *Rhus typhina*, *Hypericum perforatum* (Heinrich(2), 1976 at 877), *Syringa vulgaris* (Fye & Medler, 1954 at 78-79), and many more.

VI. HISTORIC AND PRESENT DISTRIBUTION, CONSERVATION STATUS

A. Historic Distribution

The historic distribution of *B. terricola* included the northeast southward into the higher elevations of the Appalachians, the upper Midwest extending west to the Rocky Mountains, most of southeastern Canada (Cameron, *et al.*, 2011 at 663-64) and northwest into British Columbia (Stephen, 1957 at 81). The historic range of *B. terricola* included the states of: Maine, New Hampshire, Vermont, Massachusetts, New York, Connecticut, Rhode Island, Pennsylvania, Maryland, West Virginia, Ohio, Virginia, Kentucky, Tennessee, North Carolina, Illinois, Michigan, Wisconsin, Minnesota, Montana, and the Dakotas. The species' historic range also included the Canadian provinces of Nova Scotia, New Foundland, Quebec, Ontario, Saskatchewan, Manitoba, Alberta, and British Columbia (Stephen, 1957 at 81).

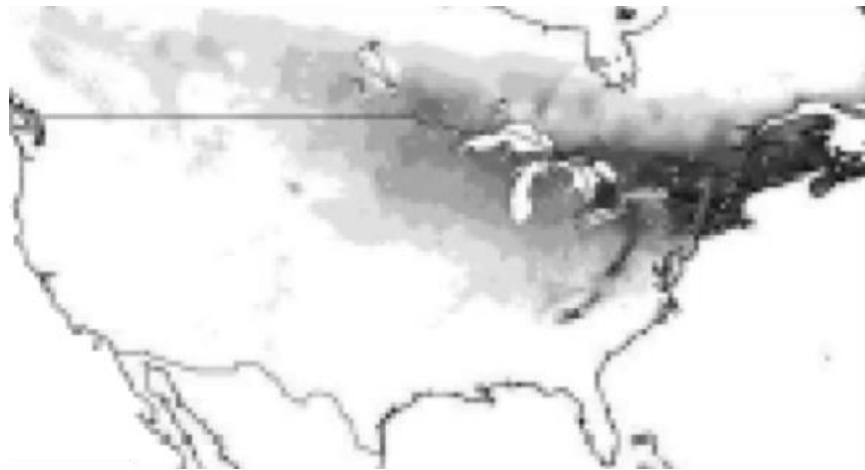


Figure 3. Historic Range of *B. terricola* - Darker areas are where *B. terricola* was more prominent (Koch & Strange, 2009 at 102).

B. Present Distribution

Recent studies suggest that *B. terricola* has experienced drastic declines throughout much of its historic range (Colla & Packer, 2008 at 1387; Cameron, *et al.*, 2011 at 664; Bushmann, 2012 at 7, 9; Grixti, *et al.*, 2009 at 79). Some collection sites have even been

completely devoid of specimens in recent years, and *B. terricola*'s range has likely contracted (Grixti, *et al.*, 2009 at 79).

Drs. Sheila Colla and Laurence Packer conducted surveys in Southern Ontario over three summers between 2004 and 2006 and compared the number of specimens collected against a large study that Dr. Macfarlane conducted in the same region between 1971 and 1973 (Colla & Packer, 2008 at 1381). Drs. Colla and Packer found that the relative abundance of *B. terricola* and three other species within the subgenus was significantly lower compared to the 1971-1973 survey (Colla & Packer, 2008 at 1384). In the 1971-1973 survey, 3,362 bumble bees were sampled and 119 of those were *B. terricola*. In the 2004-2006 survey, 1,195 bumble bees were sampled with a significantly lower relative abundance of *B. terricola*, supporting the thesis that *B. terricola* is declining in eastern North America (Colla & Packer, 2008 at 1385, 1387).

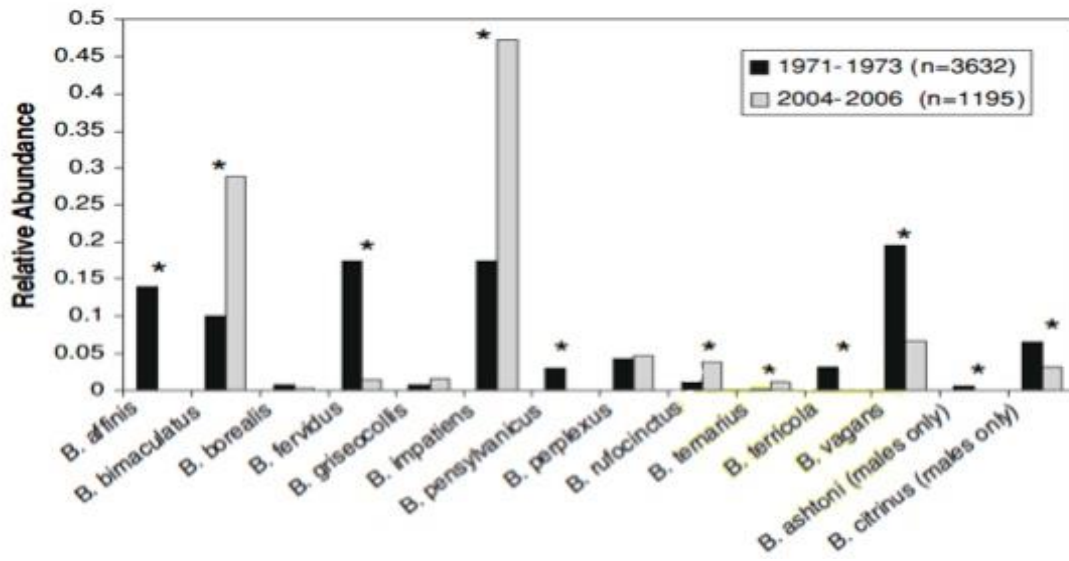


Figure 4. Relative Abundance of *B. terricola* in Ontario in two sampling year ranges (Colla & Packer, 2008 at 1384.)

Dr. Sydney Cameron conducted an extensive study from 2007-2009 that provides further evidence of *B. terricola*'s decline. Dr. Cameron focused on the relative abundance of four species of bumble bees, including *B. terricola*, thought to be in decline. Dr. Cameron assessed the relative abundance of target species by comparing nationwide historical museum collections of bumble bees from 1900-1999 (Cameron, *et al.*, 2011 at 663-64). The historical data was based on a 73,759-specimen database. After geographical adjustment, there were 3,667 historical specimens of *B. terricola* (Cameron, *et al.*, 2011 *statistical niche models* at 1). In the recent study, 382 different sampling sites throughout the United States were used and a total of 16,788 bumble bees were sampled (Cameron, *et al.*, 2011 at 662). Of that number, only 31 *B. terricola* were found. (Cameron, *et al.*, 2011, *supporting information* Table S1).

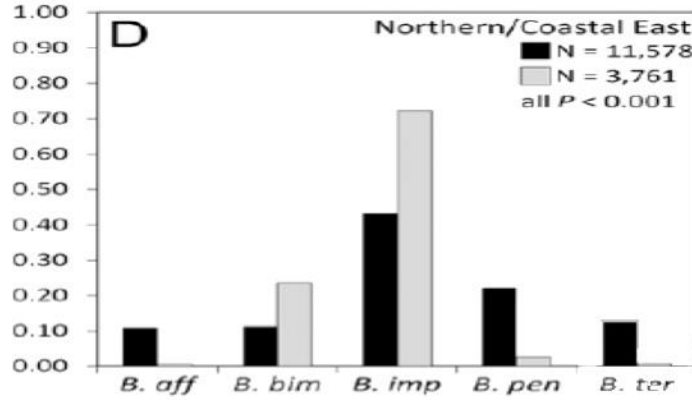


Figure 5. Relative Abundance of *B. terricola* (right): Black represents the 1900-1999 sampling, gray represents Cameron's sampling (Cameron, *et al.*, 2011 at 664).

Dr. Sara Bushmann also noted reduced abundances in a study focused on *B. terricola* in Maine. Dr. Bushmann measured the long-term relative abundance trends using data from lowbush blueberry fields from 1960-63, 1997-98, and 2009-11 (Bushmann, 2012 at 6-7). The chart in Figure 6 below shows the relative abundance of *B. terricola* found in Maine's blueberry fields for the time periods listed above. This data indicates that *B. terricola* has had pronounced reductions in abundance, notably after the mid-late 1990s (Bushmann, 2012 at 9).

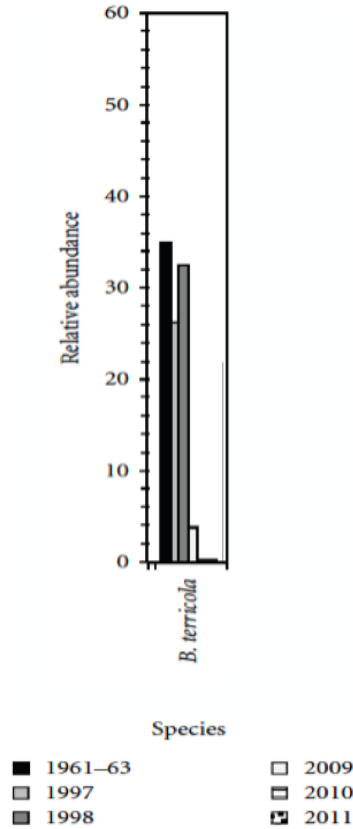


Figure 6. (Bushmann, 2012 at 7).

Extensive surveys were also conducted in the Midwest, and these surveys similarly confirm the decline of bumble bees, including *B. terricola*. In 2007, researchers conducted a survey in Illinois examining bumble bee populations across different time periods (Grixti, *et al.*, 2009 at 78). Comparing data from the Illinois Natural History Survey (INHS) database with that from the 2007 survey, the researchers examined if and how bumble bee richness and distribution has changed in response to changes in its habitat (Grixti, *et al.*, 2009 at 76). The study concluded that bumble bee species richness has declined in Illinois over the last century (Grixti, *et al.*, 2009 at 79). Between 1900-1949, there were 16 species identified, with 1,244 individual specimens of bumble bees in the INHS collection (Grixti, *et al.*, 2009 at 79). Between 1950-1999, there was an increase of individual specimens (2,674) but only 11 species were identified. Between 2000-2007 there was 3,763 individuals collected and only 12 species were found. *B. terricola* was considered rare in Illinois, but it was historically recorded within multiple areas over multiple years, indicating that *B. terricola* was not a transient species (Grixti, *et al.*, 2009 at 82). *B. terricola* was found in the sampling between 1900-1949, but was absent from both the 1950-1999 and 2000-2007 sampling periods (Grixti, *et al.*, 2009 at 79). This likely extirpation of *B. terricola* is probably a result of overall bumble bee richness declines that occurred between 1940-1960 in the Midwest as a result of agricultural intensification (Grixti, *et al.*, 2009 at 81; *see also* Section VII. A. 1. Agricultural Intensification, *infra*).

Thus, researchers agree that *B. terricola*, along with many other *Bombus* species, has been in decline for some time, with populations dropping severely in the past twenty years. While the exact causes of this decline still warrant additional research, the threats discussed below are likely contributing to *B. terricola*'s plummeting numbers.

VII. CURRENT AND POTENTIAL THREATS – SUMMARY OF FACTORS FOR CONSIDERATION

Many factors, including habitat loss, are contributing to the drastic decline in *B. terricola* populations. Habitat alterations that destroy, fragment, degrade, or reduce the bee's food supplies and nest sites all negatively impact *B. terricola* (Öckinger & Smith, 2007 at 56; Darvill, *et al.*, 2012 at 3993). Habitat loss is attributable to agricultural intensification (Hines & Hendrix, 2005 at 1481), livestock grazing (Kimoto, 2012b at 12–13), urban development (Ahrné, *et al.*, 2009 at 4; Bhattacharya, *et al.*, 2003 at 44), and fragmentation of landscapes (Öckinger & Smith, 2007 at 56).

Perhaps the most significant factor that is negatively affecting *B. terricola* is the recent introduction of non-native fungal and protozoan parasites, including *Nosema bombi* (Colla, *et al.*, 2006 at 464-65) and *Crithidia bombi* (Brown, *et al.*, 2003 at 994, 1000). In addition, pesticide application is known to negatively affect bumble bees (Gels, 2002 at 723; Thompson, 2001 at 312). Neonicotinoids are particularly harmful to bumble bees, with just trace amounts of these pesticides resulting in reduced fecundity (Laycock, *et al.*, 2012 at 1937). Similarly, insecticides have been shown to result in bumble bee deaths (*see* Thompson & Hunt, 1999 at 163) while herbicides reduce the number of suitable nesting sites and reduce the availability of floral resources (Kearns & Inouye, 1997 at 300). Lastly, global climate change is also a likely contributing factor to *B. terricola* population decline (*see* Memmott, *et al.*, 2007 at 6).

A. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range (Factor A)

Destruction, modification and curtailment of habitat are significant threats to bumble bees, including *B. terricola*. Habitat alteration, including intensive agricultural practices (Hines & Hendrix, 2005 at 1481), livestock grazing (Kimoto, 2012b at 12–13), urbanization (Ahrné, *et al.*, 2009 at 4; Bhattacharya, *et al.*, 2003 at 44), and fire suppression (Panzer, 2002 at 1297; Schultz & Crone, 1998 at 244), affect *B. terricola* by severely limiting the bumble bees' access to floral resources, destroying nesting and hibernation habitat, and contributing to a loss of genetic diversity (Goulson, 2004 at 1; Öckinger & Smith, 2007 at 56). Each of these contribute to declines in *B. terricola* populations.

Bumble bee abundance and species richness are affected by habitat fragmentation from different landscape-level disturbances (Hatfield & LeBuhn, 2007 at 155). Habitat fragmentation creates isolated patches of habitat resulting in the creation of small and isolated populations of bumble bee species (Darvill, *et al.*, 2006 at 601). Without immigration from other bee populations, these isolated populations may suffer from a lack of genetic diversity (Darvill, *et al.*, 2006 at 601, 607-08). When floral resources and nesting habitat are isolated from each other, central place foraging bumble bees like *B. terricola* may be unable to utilize them, negatively affecting their populations (*see* Öckinger & Smith, 2007 at 56). Consequently, continued habitat fragmentation and isolation of foraging and nesting sites could have a negative effect on *B. terricola* populations. The reduction of foraging habitat due to fragmentation has been shown to increase inbreeding, especially in populations limited to less than 15 square kilometers of suitable habitat (Darvill, *et al.*, 2012 at 3993).

Additionally, habitat fragmentation may lead to a loss of genetic diversity in bee populations that are isolated from other remaining populations (Ellis, *et al.*, 2006 at 4384). A loss of genetic diversity among bumble bee populations could lead to inbreeding depression, making it difficult for the bees to respond to changes in the environment (Darvill, *et al.*, 2006 at 601, 608). Evidence now shows that inbreeding also contributes to declines in both individual bee and overall bee population performance (Darvill, *et al.*, 2006 at 601, 608; Goulson, 2008 at 197). This is discussed in depth in Section VII. D. 5. Population Dynamics and Structure, *infra*.

Loss of plant diversity in agricultural habitats has been linked to a decline in bee diversity (Le Féon, *et al.*, 2010 at 147). Grasslands have declined significantly in the United States and are considered a critically endangered ecosystem (Noss, *et al.*, 1995 at 7).

1. Agricultural Intensification

Intensive agricultural practice is synonymous with the high use of pesticides³ and fertilizers, increased mechanization and farm size, as well as a focus on high productivity (Le Féon, *et al.*, 2010 at 143). These practices directly harm bees, impact the availability of floral and other habitat resources, and likely contribute to declines in species richness, abundance, and diversity. In North America, trends show declines of bumble bee populations in native

³ The impact of pesticides is discussed in Section VII. C. 2. Pesticides, *infra*.

habitats that have been altered by agricultural practices (Grixti, *et al.*, 2009 at 76; Hines & Hendrix, 2005 at 1477). Likewise, studies from Europe show that agricultural intensification and changes in land-use and farming practices contribute to declines in bumble bee richness and abundance (Le Féon, *et al.*, 2010 at 143, 148; Carvell, *et al.*, 2006 at 481, 486; Goulson, *et al.*, 2004 at 1; Goulson, *et al.*, 2008 at 193).

Intensive agricultural practices fragment and alter native grasslands and reduce the available habitat for bumble bees. Bumble bee diversity and abundance is positively related with the abundance of floral resources and tall grass prairie habitat patches (Hines & Hendrix, 2005 at 1481; *see also* Kimoto, *et al.*, 2012a at 15). Native tall grass habitats are typically abundant in floral resources that bumble bees utilize as food sources and suitable nesting sites (Hines & Hendrix, 2005 at 1477-1478). Native grasslands and the marginal grassy areas surrounding them are also common nesting sites for bumble bees (Hines & Hendrix, 2005 at 1483; Kimoto, *et al.*, 2012a at 15). The loss of these areas is likely contributing to the decline of bumble bees nationwide.

In agricultural areas, some mass flowering crops provide nectar and pollen resources for bumble bees that can lead to increased densities of bumble bees and colony growth (Westphal, *et al.*, 2003 at 964). However, the increased planting of genetically modified crops that are tolerant to herbicides leads to increased use of those herbicides, thus reducing the availability of wildflowers in agricultural field margins (Pleasants & Oberhauser, 2013 at 136, 143). The loss of plant diversity close to nesting sites may decrease foraging access, as Drs. John Pleasants and Karen Oberhauser demonstrated with the Monarch butterfly (Pleasants & Oberhauser, 2013 at 136, 143). Likewise, genetically modified crops can create monocultures shown to harm the reproductive success of bumble bees (Westphal, *et al.*, 2009 at 191-92; Goulson, *et al.*, 2008 at 193). Monocultures typically provide floral resources only for a short period of time, whereas bumble bee colonies need them throughout their colony life cycle from early spring to late fall (Westphal, *et al.*, 2009 at 192; *see also* Goulson, *et al.*, 2008 at 193). As a result of these threats, agricultural intensification poses a serious threat to *B. terricola*.

2. Livestock Grazing

Livestock grazing is one of the most common land uses in Western North America (Kimoto, 2010 at 1; *see also* Kimoto, 2012b at 2). *Bombus* as a genus are sensitive to grazing (Kimoto, 2010 at 85). Studies conducted both in North America and in Asia have shown that unmanaged or excessive grazing negatively impacts the floral and nesting resources of bumble bees, contributing to a decline in overall bee abundance and richness (Kimoto, 2012b at 10, 12–13; Hatfield & Lebuhn, 2007 at 154; Xie, *et al.*, 2008 at 700-01). Livestock animals have a disproportionate effect on the ecosystems in which they are introduced (Vazquez & Simberloff, 2003 at 1081). Herbivores like cattle and sheep may have a disproportionately strong impact on the plant-pollinator relationship in that same ecosystem (Vazquez & Simberloff, 2003 at 1081).

Selective defoliation, trampling, and nitrogen deposition from livestock grazing shape plant community structure and diversity (Schohier, *et al.*, 2013 at 287). Low grazing intensity preserves floral resources benefitting bumble bees (Schohier, *et al.*, 2013 at 287, 292).

However, in highly grazed areas, the height of floral resources decreases significantly, which can lead to decreases in species richness and abundance (Xie, *et al.*, 2008 at 701).

Because livestock grazing also disturbs the soil, it could negatively impact bee nesting sites. Bumble bees often nest in abandoned rodent burrows (Sugden, 1985 at 300). Bumble bee colonies construct delicate chambers in those burrows close to the surface (Sugden, 1985 at 300). Grazing inherently leads to disturbance of the ground surface, and thus livestock grazing could destroy the colony and thus-far-unused potential nesting sites (Sugden, 1985 at 300). As a result, livestock grazing is a threat to *B. terricola*.

3. Urban Development

Urban development, like agricultural intensification causes habitat fragmentation that likely contributes to bumble bee population declines. Urban areas consistently contain high levels of impervious surfaces, which have a negative impact on bumble bee diversity (Ahrné, *et al.*, 2009 at 1, 3 (fig. 1), 4). These surfaces include buildings, roads, railroads, industrial areas, and other man-made barriers. Impervious surfaces increase in proportion relative to the decrease in green areas suitable for bumble bee habitat (Ahrné, *et al.*, 2009 at 4, 6). Thus, bumble bee abundance and species composition are also affected as the proportion of impervious surface increases relative to the decrease in natural areas (Ahrné, *et al.*, 2009 at 1, 3-4).

Urban areas fragment bumble bee habitat by isolating floral resources, which reduces movement of bumble bees between these patches of habitat (Bhattacharya, *et al.*, 2003 at 44). This may lead to smaller, more isolated populations of bumble bees and a reduction of gene flow between the fragmented populations of plant species that depend on bumble bee visitation (Bhattacharya, *et al.*, 2003 at 44). This, in turn, can cause a reduction of adequate gene flow between bumble bee colonies reliant on the plant species.

Adequate gene flow in species helps to prevent inbreeding and maintain adaptive genetic variation (Jha & Kremen, 2013 at 2483). Bumble bees require nesting and dispersal across landscapes to maintain this flow (Jha & Kremen, 2013 at 2483). Human-altered landscapes such as urbanized areas can fragment the populations of species and reduce native pollinators, including bumble bees (Jha & Kremen, 2013 at 2492). Drs. Shalene Jha and Claire Kremen's 2013 study was the first to demonstrate that "bumble bee gene flow patterns can be limited by impervious land use and appear to be particularly sensitive to recent land use patterns." (Jha & Kremen, 2013 at 2492).

Urban green spaces may provide a safe-haven for bumble bees by containing floral and nesting resources (Frankie, *et al.*, 2005 at 235; McFrederick & LeBuhn, 2006 at 372). However, some floral resources are slowly being transformed by anthropogenic disturbances that compact the soil and facilitate introduction of invasive plant species that eventually lead to the loss of native plants (McFrederick & LeBuhn, 2006 at 373). With added species competition in these increasingly scarce urban areas, native bumble bee diversity and richness have shown an associated decline (McFrederick & LeBuhn, 2006 at 379).

Urban development functions as the ultimate habitat disruptor by creating areas where bumble bees simply cannot survive. Even if some colonies survive around impervious

surfaces, the loss of genetic diversity weakens populations, making them more susceptible to the other threats discussed in this petition.

4. Fire and Fire Suppression

Natural and manmade fire has historically been an important factor in native grasslands. Fires caused by lightning as well as those set by Native Americans were historically used to maintain grasslands (Schultz & Crone, 1998 at 244). Fire suppression can ultimately lead to the loss of grasslands (*see* Panzer, 2002 at 1297; Schultz & Crone, 1998 at 244). Grasslands have dramatically declined since the inception of fire suppression techniques. Fire suppression degrades the native grassland ecosystem by facilitating the invasion of shrubs and trees (Panzer, 2002 at 1297). Invasive weeds and encroachment of forests threaten the survival of grasslands (Schultz & Crone, 1998 at 244).

Fire suppression also leads to increased fuel loads and tree densities, which can cause severe, high-intensity fire (Huntzinger, 2003 at 1). Fire suppression in forested habitats has contributed to rising tree lines in the Rocky Mountain region (Roland & Matter, 2007 at 13702). The rise in tree lines contributes to fragmentation of alpine meadows, leading to forest encroachment and population isolation within these meadows (Roland & Matter, 2007 at 13702). The resulting habitat fragmentation reduces dispersal and foraging opportunities for populations living in these meadows, increasing the likelihood of species extinction (Roland & Matter, 2007 at 13702). Grasslands covered about 42% of the earth's surface historically (Kimoto, 2012a at 2). Grasslands now only cover less than 13% of the surface of the earth (Kimoto, 2012a at 2). The decline in grasslands of the Northwest is particularly concerning for *B. terricola* and other native bees because grasslands support rich native bee fauna (Kimoto, 2012a at 15). Fire suppression, and the resulting loss of grassland ecosystems, is therefore likely having a negative impact on *B. terricola* populations within its range.

B. Disease or Predation (Factor C)

A major cause of the decline in *B. terricola* can be attributed to pathogens that have been recently introduced into wild bumble bee populations throughout the United States. Specifically, these include the exotic strain of the microsporidium *Nosema bombi*, the protozoan parasite *Crithidia bombi*, the tracheal mite *Locustacarus buchneri* and the Deformed Wing Virus (Colla, *et al.*, 2006 at 462).

These diseases most likely originated in, or can be attributed to, commercially reared bumble bees used for greenhouse pollination. Commercially reared bumble bees frequently harbor pathogens and their escape from greenhouses can lead to infections in native species (Colla, *et al.*, 2006 at 465-66). Once infected, colonies exhibit reduced survival and reproduction rates as well as diminished foraging efficiency (Brown, *et al.*, 2003 at 1000; Gegear, *et al.*, 2005 at 213; Otterstatter, *et al.*, 2005 at 387). According to the National Academy of Sciences National Research Council (NRC) report on the Status of Pollinators in North America, "pathogen spillover" from infected commercially reared bumble bees is responsible for the recent declines in some native bumble bee populations and may also be the most important factor responsible for the likely extinction of *B. franklini* (NRC, 2007 at

8, 87-89). Thus, pathogens present a profound risk to wild bumble bee populations throughout North America.

1. *Nosema bombi*

N. bombi is a microsporidium that infects bumble bees primarily in the malpighian tubules (small excretory or water regulating glands), but also in body fat, nerve cells, and sometimes the tracheae (Otti & Schmid-Hempel, 2007 at 119). Infected bumble bee colonies, including infected colonies of the closely-related *B. occidentalis*, can appear to be healthy but still carry the disease and transmit it to other colonies (see Koch & Strange, 2012 at 218; see also Larson, 2007 at 3). The effect of *N. bombi* on *B. occidentalis* varies from mild to severe (Otti & Schmid-Hempel, 2007 at 118, 119, 123; see also Larson, 2007 at 3). Scientists have observed *N. bombi* in wild bumble bees throughout North America, including *B. terricola* (Colla, *et al.*, 2006 at 464; Cordes, *et al.*, 2012 at 212, tbl. 2, 214).

Dr. Robbin Thorp hypothesizes that *N. bombi* is the most probable cause for the decline of the closely-related *B. occidentalis* (Evans, *et al.*, 2008 at 24). Dysentery is the main symptom found in bumble bees infected with *N. bombi* (Koch & Strange, 2012 at 213). *N. bombi* also detrimentally affects bees by lowering their mating success, ability to survive in the winter, and ability to establish colonies (Koch & Strange, 2012 at 213; Colla, *et al.*, 2006 at 466; Otti & Schmid-Hempel, 2007 at 123). *N. bombi* reduces the colony's fitness, reduces the individual bee's reproduction rate, and reduces the individual bee's life span (Colla, *et al.*, 2006 at 462; Otti & Schmid-Hempel, 2007 at 123; van der Steen, 2008 at 273, 278-79, 281; Rutrecht & Brown, 2009 at 946).

Scientists have shown that *N. bombi* spreads from commercial bumble bees, utilized in greenhouses, to wild bumble bees through shared pollination (Colla, *et al.*, 2006 at 462, 465). Significant evidence suggests that commercially-reared bumble bees possess a higher prevalence of various pathogens than their wild counterparts (Colla, *et al.*, 2006 at 462). Commercially-reared bumble bees routinely forage outside the greenhouses where they are utilized when alternative food sources are available (Whittington, *et al.*, 2004 at 599, 601). *N. bombi* is likely spread to wild bumble bees when both wild and commercial bees pollinate the same flowers (Colla, *et al.*, 2006 at 462).

Scientists have also transmitted European origin *N. bombi* to two native Japanese bumble bees, thereby showing that the potential hosts for *N. bombi* are wide ranging (Larson, 2007 at 9). Furthermore, University of Illinois at Urbana-Champaign researchers discovered that an *N. bombi* strain found in multiple species of North American bumble bees is genetically very similar to that found in European bumble bees (Cordes, *et al.*, 2012 at 215).

The NRC report on the Status of Pollinators in North America reviewed several studies suggesting that when heavily infected commercial colonies come into contact with wild bumble bee populations, pathogens can be introduced in nearby wild populations (NRC, 2007 at 88-89). The NRC also states that the recent disappearance of the closely-related *B. occidentalis* from the western part of its range was likely caused by pathogen spillover from infected commercially reared bumble bees (NRC, 2007 at 88). Additionally, the Service has recognized that *N. bombi* poses a threat to all bumble bee populations generally and that it is easily transferred from commercial to wild bumble bees. 76 Fed. Reg.

at 56,381, 56,388 (Sept. 13, 2011). Therefore, the available information indicates that *N. bombi* is likely negatively impacting *B. terricola*, especially where the species may come into contact with commercially reared bees.

2. *Crithidia bombi*

Crithidia bombi is an internal protozoan parasite that is also likely a cause of the decline of *B. terricola*. This parasite adversely impacts the bee's entire lifecycle from the queen's colony founding success, to the fitness of established colonies, as well as the survival and foraging efficiency of worker bumble bees (Brown, *et al.*, 2003 at 994, 1000; Otterstatter, *et al.*, 2005 at 388; Gegear, *et al.*, 2005 at 213; Gegear, *et al.*, 2006 at 1075-76). Particularly high mortality rates from *C. bombi* are present in hosts that are already under stress from other threat factors (Brown, *et al.*, 2000 at 421, 425-26).

Like *N. bombi*, *C. bombi* is commonly found in bumble bees near greenhouses (Colla, *et al.*, 2006 at 461, 463). One study found infection rates as high as 47% within 30 meters of commercial greenhouses, with infection rates dropping proportionately as the distance from the greenhouse increased (Otterstatter & Thomson, 2008 at 3). As with *N. bombi*, scientists believe the parasite spreads from commercially reared bumble bees to wild species through the shared pollination of flowers (Durrer & Schmid-Hempel, 1994 at 299, 301). More recently, researchers have shown that honey bees may also be a possible vector for *C. bombi*, by carrying and passing the parasite on to various bumble bee species (Ruiz-González & Brown, 2006 at 616, 620-21). Finally, the Service has recognized that *C. bombi* poses a threat to all bumble bee populations generally and that it is easily transferred from commercial to wild bumble bees. 76 Fed. Reg. at 56,388. Therefore, *C. bombi* is also a likely cause of *B. terricola*'s population declines.

3. *Locustacarus buchneri*

The tracheal mite, *Locustacarus buchneri*, is also prevalent in the closely-related *B. occidentalis* (Otterstatter & Whidden, 2004 at 355). Like the microparasite *N. bombi*, *L. buchneri* is much more common in commercially reared European bumble bees. Studies report the infestation rate in certain commercially raised bees at 17 to 20% compared to a 1 to 8% infestation rate in particular wild bees. Scientists believe that mites could spread through drifting workers or pollinating shared flowers (Goka, *et al.*, 2001 at 2098). *L. buchneri* can accumulate in the workers and cause lethargy and a cessation of foraging (Goka, *et al.*, 2001 at 2095).

Further, bumble bees in the sub-genus *Bombus sensu stricto*, such as *B. terricola*, appear to be more susceptible to tracheal mite infestation than other bumble bees, exhibiting a higher infestation rate (Otterstatter & Whidden, 2004 at 355). Finally, the Service has recognized that *L. buchneri* poses a threat to all bumble bee populations generally and that it is easily transferred from commercial to wild bumble bees (76 Fed. Reg. at 56,388). Therefore, *L. buchneri* is likely negatively impacting *B. terricola* populations.

4. Deformed Wing Virus

Lastly, Deformed Wing Virus (DWV) may contribute to the decline of *B. terricola*. DWV causes crippled wings, rendering bees unable to fly and forage (*see* Otti & Schmid-Hempel, 2007 at 123; Genersch, *et al.*, 2006 at 61). This ultimately poses a serious threat to bumble bee populations. DWV, originally a disease found only in honey bees, has recently been observed in bumble bee populations (Genersch, *et al.*, 2006 at 61). DWV was first observed in 2004 in bumble bee queens in European commercial operations (Genersch, *et al.*, 2006 at 61). Honey bees are frequently used in breeding facilities to encourage bumble bee queens to initiate nesting behavior (Genersch, *et al.*, 2006 at 61–62). Consequently, the two species come into close contact in these facilities. DWV was also observed in a wild population of bumble bees found in Germany. This colony of bumble bees had previously been known to rob nectar from nearby honey bee hives (Genersch, *et al.*, 2006 at 62). The strain of DWV found in both of these bumble bee populations was of a higher virulence than its honey bee counterpart (Genersch, *et al.*, 2006 at 63).

Commercial bumble bee rearing operations are likely the source of the spread of DWV from honey bees to bumble bees, but honey bees may also be able to spread the disease to bumble bees in the wild (Evans, *et al.*, 2008 at 32). DWV also causes wing crippling in bumble bees as well as honey bees (Genersch, *et al.*, 2006 at 63). DWV may also show a higher virulence in bumble bees (Genersch, *et al.*, 2006 at 63). Additionally, the Service has recognized that DWV poses a serious threat to bumble bee populations. 76 Fed. Reg. at 56,388. Given that infections have occurred in both commercial and wild populations, DWV likely poses a serious threat to *B. terricola* populations.

C. The Inadequacy of Existing Regulatory Mechanisms (Factor D)

Congress and regulatory agencies have failed to take action on the collapsing U.S. bumble bee population. While scientific evidence stacks up regarding the likely causes of population declines, little government action has occurred in response. *B. terricola* and its habitat are not directly protected under Federal or State law, nor does any law prohibit the taking of this species.

Furthermore, there are no regulations that limit the interstate transport of bumble bees and therefore no regulations that would curb the spread of disease. Currently, U.S. Department of Agriculture regulations promulgated under the Honey Bee Act permit honey bees to be imported from Canada, Australia, and New Zealand. 7 C.F.R. § 322.4. Department of Agriculture regulations also permit the import of two species of bumble bees, *B. occidentalis* and *B. impatiens* from Canada. 7 C.F.R. § 322.5. Only California and Oregon restrict the importation of commercial bumble bees.

Due to the high rates of pathogen infection in commercially reared bumble bees, regulations must address the transport of both foreign and domestic bees to be effective. In addition, there are no regulations that limit the interstate transport of bumble bees and therefore no regulations that would curb the spread of disease.

As discussed above, disease and pesticide use are the greatest threats to bumble bees. The existing regulatory mechanisms are inadequate to protect *B. terricola* from these threats.

1. Disease

Measures to reduce the transmission of disease from commercially reared bees to wild *B. terricola* populations are scarce in the United States. Although the Animal Plant Health Inspection Service (APHIS) requires an export certificate from the country of origin for honeybees that must identify diseases or parasites of concern, the diseases that threaten *B. terricola* are not specifically listed. 7 C.F.R. § 322.6. Furthermore, the regulations do not require that diseases or parasites be listed on export certificates of “bees other than honeybees,” which would include all commercially reared *Bombus* species. 7 C.F.R. § 322.6(c). This enables diseases to continue to be spread throughout native populations of *B. terricola* by the import of commercially reared bees. Additionally, APHIS does not regulate the movement of bees across State lines once the bees are in the United States (APHIS Petition, 2010 at 13) (stating that “APHIS ceased to regulate the interstate movement of bumble bees in 1998”). The Service has acknowledged that this existing regulatory scheme might be inadequate to protect against the spread of disease among bumble bees in North America. 76 Fed. Reg. at 56,389.

In 2010, The Xerces Society, Defenders of Wildlife, the Natural Resources Defense Council, and Dr. Robbin Thorp petitioned the Secretary of Agriculture and APHIS urging the agency to regulate commercial bumble bees (APHIS Petition, 2010). Specifically, the group requested that commercial bumble bees be certified as disease free before crossing state lines within their native ranges and that APHIS prohibit the movement of bumble bees outside of their native ranges (APHIS Petition, 2010 at 2). APHIS did not respond to the initial petition (DOW Letter to APHIS, 2013 at 1). In October of 2013, the petitioners renewed their efforts and asked the Secretary of Agriculture to take action on their petition (DOW Letter to APHIS, 2013). It is unclear if APHIS has taken any action on the petition as there have not been any Federal Register or other public notices of a proposed rulemaking on these issues. Without adequate regulation of commercial bumble bees, diseases may continue to be transmitted to native populations of *B. terricola*. The current regulations are inadequate to protect *B. terricola* against this threat.

2. Pesticides⁴

The detrimental effects of pesticides on bumble bees and other pollinators is becoming increasingly clear as colonies continue to collapse. Pesticide regulations do exist, but none are specific to the protection of bumble bees. State legislatures are attempting to control the use of pesticides in their own capacity and Europe has banned neonicotinoid pesticides for at least two years until more studies can be conducted. The United States is beginning to shift focus to neonicotinoids as well, but to date there are no effective regulations of these pesticides to protect bumble bees in the United States.

The Environmental Protection Agency regulates the use of pesticides in the United States under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). Pesticides need to be registered (licensed) with the EPA, which must ensure each pesticide on the list continues to meet the “highest

⁴ The pesticide threat is treated in detail in Section VII. C. 2. Pesticides, *infra*.

level of safety to protect human health and the environment.” (EPA: Reevaluation of Pesticides, 2014 at 1). In response to the concern over the status of pollinators, the EPA has accelerated its review of neonicotinoid pesticides and results should be available between 2016-2019 (EPA (4): Schedule for Review of Neonicotinoid Pesticides, 2014). Since 2011, EPA has conducted pollinator risk assessments for pesticide registrations under FIFRA that determine likelihood of exposure and impact of the pesticide. Due to the heightened awareness of pesticide use and new data, EPA has recently announced that it is not likely to approve any new uses for neonicotinoids (EPA I, 2015). However, EPA has not restricted current uses of neonicotinoids.

In response to scientific studies on the sub-lethal effects of neonicotinoids (EFSA 1-3, 2013) the European Union (EU) amended its previous regulations of neonicotinoids and banned the use of three types of neonicotinoids because of their effects on bees (Commission Implementing Regulation (EU) No 485/2013, p. 139/13). However, *B. terricola* is not native to Europe, so these actions will have no effect on the species. Similar legislation has been introduced in Congress, in some state legislatures, and even recently at the local level.

Representative John Conyers recently reintroduced the Save America’s Pollinators Act of 2015 (H.R. 1284). This bill directs the EPA Administrator to suspend the registration of neonicotinoids until a determination can be made that neonicotinoids will not cause unreasonable adverse effects on pollinators based on; (1) the best scientific evidence, and (2) a complete comprehensive field study that is completed which meets the criteria of the Administrator (H.R. 1284 (2015), p.7). Currently the bill is co-sponsored by 35 Democratic and one Republican House members (as of May 17, 2015). Given the lack of majority Republican support for the legislation and general anti-regulatory agenda of the governing party, it is unlikely to be enacted into law in the current term. As a result, effective federal protections are lacking and will likely continue to be lacking, at least in the short term.

In some instances, states and local communities have been taking the lead on pesticide regulation. Oregon has issued a temporary emergency rule regulating the use of two neonicotinoids. Under this rule, the use of dinotefuran and imidacloprid on Linden trees or other *Tilia* spp. are prohibited from June 26 – December 23, 2014 (State of Oregon, 2014). The rule was passed in response to the death of over 50,000 bumble bees from an improper application of a neonicotinoid pesticide in two separate towns in 2013 (KPTV, 2013). However, this regulation only covers certain applications of two neonicotinoids for part of the year in one state. This rule is also classified as being “temporary,” meaning that any protections it may offer could disappear if it were not renewed. As of November 3, 2014, Minnesota is also considering a statewide ban of neonicotinoids (MN. Bill HF 2798). Other states such as New Jersey and Minnesota have bills to regulate or ban neonicotinoids pending in their state legislatures. None of these proposals is currently providing any level of concrete protection. However, Eugene Oregon recently passed a resolution to ban the use of any product containing neonicotinoids on “any city property.” (Eugene Res. 2014). While this is a step in the right direction it only addresses city property in one town. This is clearly inadequate for a species facing range-wide threats.

Even though some of the measures mentioned above attempt to protect *B. terricola* and other pollinators, the regulation of commercially reared bumble bees across state lines,

stricter measures on pesticides at the Federal and State levels, and regulations for the protection of bumble bee habitat to ensure the continued survival of *B. terricola* are lacking and do not appear to be coming anytime soon. The currently-existing regulatory mechanisms are simply inadequate to protect the species.

D. Other Natural or Manmade Factors Affecting *B. terricola*'s Continued Existence (Factor E)

Bumble bees, including *B. terricola*, are threatened by several other natural or manmade factors, including the use of pesticides (Thompson & Hunt, 1999 at 147), population dynamics and structure (Darvill, *et al.*, 2006 at 601), and global climate change (NRC, 2007 at 100). The multiple threats that these bumble bees face are dangerous independently, but also may interact with one another to create a greater threat to the species than their additive impact alone (Williams & Osborne, 2009 at 371; Laycock, *et al.*, 2012 at 1937).

1. Pesticides

Pesticide application threatens the entire *Bombus sensu stricto* sub-genus as well as bumble bees more generally (Evans, *et al.*, 2008 at 29; Thompson & Hunt, 1999 at 147). The NRC Report on the Status of Pollinators notes that pesticides may be having dramatic detrimental effects on honey bee population in North America (NRC, 2007 at 79-80). Additionally, many common pesticides are applied in the late evening or early morning, which overlaps times when bumble bees are foraging (Thompson, 2001 at 305), making it likely that bumble bees will come into direct contact with pesticides. Aerial pesticide sprays can also kill up to 80% of foraging bees near the pesticide's source while drifts can continue to be dangerous for more than a mile from the source (Evans, *et al.*, 2008 at 29 (citing Johnsen & Mayer, 1990)). In addition, bumble bees that forage on pesticide-sprayed fields that have not been irrigated following pesticide application suffer reduced foraging, colony weight, and other negative effects. Finally, the Service has noted that pesticides pose a serious threat to rare invertebrates in general, 76 Fed. Reg. at 56,390, 56,391, which would include *B. terricola*.

Numerous studies on the use of pesticides and its effect on bumble bees have found that pesticide use may cause bumble bee population declines. For example, researchers noted that in 1995 there were numerous dead and dying bumble bees in a nearby garden following pesticide use on oil rape seed in full flower (Thompson & Hunt, 1999 at 163). In 1996, another incident linking bumble bee deaths to application of pesticide to field beans in full flower was reported (Thompson & Hunt, 1999 at 163). In a third incident reported in 1997, pesticide was used on full flower oil rape seed, and two days later dead bumble bees were reported (Thompson & Hunt, 1999 at 163). In addition, populations of bumble bees declined in blueberry fields near sprayed forests (Kearns, *et al.*, 1998 at 91). Bumble bee deaths were also reported in the United Kingdom following applications of dimethoate and alphacypermethrin to oilseed rape and following application of cyhalothrin to field beans (Goulson, *et al.*, 2008 at 195).

In addition to pesticide threats in general, the increased uses of persistent neonicotinoid pesticides has been shown to be highly toxic to bees and may be a substantial threat to bumble bees in particular (Colla & Packer, 2008 at 1388). Neonicotinoids are

among the most effective and widely used pesticides utilized to control common insect pests such as aphids and whiteflies (Elbert, *et al.*, 2008 at 1099; *see also* Colla & Packer, 2008 at 1388). They are synthetic neurotoxins that lethally disrupt the pest's nervous system (Laycock, *et al.*, 2012 at 1937-38). Neonicotinoids are applied as a seed dressing or sprayed on a plant's leaves and are then taken up by the plant and distributed systemically (Sur & Stork, 2003 at 35-36) to target pest herbivores that consume sap and plant tissues. Studies have shown that honeybees are non-target organisms that ingest dietary residues of neonicotinoids in the nectar and pollen of treated mass-flowering crops (Rortais, *et al.*, 2005 at 77). While these studies focused exclusively on honeybees, neonicotinoids have been shown to be toxic to bumble bees, particularly when applied in violation of labeling, during flowering periods (Larson, 2014 at 257).

When bumble bees are exposed to even trace residues of neonicotinoids, the effects can be severe. A recent study examining neonicotinoid pesticides applied in environmentally realistic doses showed that such applications substantively reduced the fecundity of bumble bees. The study determined that trace dietary amounts of neonicotinoid pesticides can reduce worker fecundity by at least one third (Laycock, *et al.*, 2012 at 1937).

In addition, two recent studies have confirmed theories that neonicotinoids are causing bee declines. First, Dr. Maj Rundlof demonstrated that neonicotinoid coated seeds led to "reduced wild bee density, solitary bee nesting, and bumble bee colony growth and reproduction under field conditions." (Rundlof, *et al.*, 2015 at 77). Dr. Sebastian Kessler showed that instead of bees avoiding neonicotinoids as some had theorized, they actually grew addicted to some neonicotinoid additives and would likely visit those plants more, thus increasing exposure (Kessler, *et al.*, 2015 at 74). Both studies conclude that the contribution of neonicotinoids to bee decline may be underestimated.

As a result, both pesticides in general and neonicotinoids specifically represent a serious threat to *B. terricola's* persistence.

2. Insecticides

Direct exposure to insecticides is toxic to bee populations (Gels, 2002 at 723). Bees may also suffer indirect negative effects as a result of indirect exposure to insecticides (Gels, 2002 at 723). Bees are exposed to insecticides in three different ways: through sprays of insecticides on crops and wild flowers, consumption of contaminated nectar, or contact with foliage that is covered in insecticides (Goulson, *et al.*, 2008 at 194). Insecticides used in the spring are especially harmful to bumble bee populations because this is when queens forage and colonies are still small (Goulson, *et al.*, 2008 at 194). Researchers have also associated the organophosphate insecticides, such as Fenitrothion, with bee poisonings in food crops (Kearns, *et al.*, 1998 at 91). Insecticides used for turf management in golf courses and urban parks also pose a risk to bumble bees (Gels, *et al.*, 2002 at 722).

3. Herbicides

Herbicides reduce the availability of floral resources (Smallidge & Leopold, 1997 at 264), and may negatively affect the ability of bumble bees to forage or return to their nests (Thompson, 2001 at 312). Therefore, herbicides pose yet another threat to bumble bee

populations by killing their food plants (Williams & Osborne, 2009 at 373, 374). Herbicides are used in agricultural and other industries for controlling weed species. However, their use indiscriminately removes important nectar resources and causes bumble bee population declines (Kearns, *et al.*, 1998 at 91; Williams & Osborne, 2009 at 374). Dr. Carol Kearns noted that “herbicide use affects pollinators by reducing the availability of nectar plants. In some circumstances, herbicides appear to have a greater effect than insecticides on wild bee populations... Some of these bee populations show massive declines due to the lack of suitable nesting sites and alternative food plants.” (Kearns, *et al.*, 1998 at 91-92).

4. Population Dynamics and Structure

Bumble bees are haplodiploid organisms (*see* Zayed & Packer, 2005 at 10742). The sex of offspring is determined by the unique number of alleles at the sex-determining locus (*see* van Wilgenburg, *et al.*, 2006 at 2). Males are haploid and come from unfertilized eggs while females are diploid and come from fertilized eggs (NRC, 2007 at 95). As a result of this sex determination system, bumble bees will have lower population sizes in general compared to diploid organisms (Packer & Owen, 2001 at 8). Lower population size and inbreeding are particularly detrimental to bumble bees (van Wilgenburg, *et al.*, 2006 at 3). When bumble bees engage in sib-mating (where brother and sister bees mate), there is an increased chance that the offspring could be a diploid male, instead of the normal diploid female (van Wilgenburg, *et al.*, 2006 at 3). Many diploid males are sterile (Zayed & Packer 2005 at 10743; van Wilgenburg, *et al.*, 2006 at 2). When a diploid male is able to mate, they produce sterile triploid offspring that will reduce the proportion of fertile individuals in the population further (Whitehorn, *et al.*, 2009 at 2). Diploid males are produced in place of female workers, which can reduce colony fitness, including lower survival and growth rates, and create colonies that have reduced numbers of offspring (Whitehorn, *et al.*, 2009 at 2; *see also* Darvill, *et al.*, 2006 at 608). This could lead to a loss of genetic diversity (*See* Whitehorn, *et al.*, 2009 at 5–6).

Populations without frequent immigration are also susceptible to the loss of genetic diversity “through bottlenecks and drift.” (Darvill, *et al.*, 2006 at 601, 608). This loss of genetic diversity can lead to inbreeding depression within the fragmented population that reduces both “individual and population performance” and overall fitness (Darvill, *et al.*, 2006 at 601, 602, 608).

Inbreeding and reduced genetic diversity can lead to a reduction in adult longevity, larval survival, egg hatching rates (Darvill, *et al.*, 2006 at 601, 608; Packer & Owen, 2001 at 21), and an increased susceptibility to disease and parasites (Whitehorn, *et al.*, 2010 at 1195, 1200). The reduction of genetic diversity in bumble bees and corresponding increase in disease and parasite prevalence may lead to increased susceptibility to environmental pressures, or even extinction (Cameron, *et al.*, 2011 at 665; Whitehorn, *et al.*, 2010 at 1195, 1200). The Service has also recognized that low genetic variability is a threat to rare invertebrate populations. 76 Fed. Reg. at 56,390, 56,391. This therefore represents a threat to *B. terricola*'s ongoing existence.

5. Climate Change

Climate change will likely threaten *B. terricola* by disrupting habitat and altering floral resources (see Memmott, *et al.*, 2007 at 1, 4, 5). Changes in temperature and precipitation, increased frequency of temperature and precipitation extremes, early snow melt, late frost events, and increased drought are just a few of the likely causes of these disruptions.

As the climate warms, the distribution of plants that pollinators rely on may change (see Forrest, *et al.*, 2010 at 438, 439; Inouye, 2008 at 361). Localized studies in the eastern U.S. have shown that some plants are flowering earlier than they were in the past (Abu-Asab, *et al.*, 2001 at 598; Primack, *et al.*, 2004 at 1261). This can lead to phenological asynchrony between the plants and pollinators (Memmott, *et al.*, 2007 at 4; Thomson, 2010 at 3197), meaning that the bees and the plants that they rely on are out of sync, potentially posing an extreme threat to species, like *B. terricola*, that are entirely reliant on these plants for food.

Climate change may also be causing exotic and invasive plant and insect species to thrive in areas not within their native ranges (Willis, 2010 at 1-2). More invasive plants increases competition with native plant species, which in turn will cause a reduction in requisite floral resources for native bumble bees (Morales & Travaset, 2009 at 723). As this invasive plant problem continues to grow it will exert further pressure on *B. terricola*.

VIII. CONCLUSION

B. terricola's numbers have fallen drastically in recent years (Colla & Packer 2008 at 1387; Cameron, *et al.*, 2011 at 664; Bushmann, 2012 at 9; Gixti, *et al.*, 2009 at 79). Some studies have found reduced numbers compared with historic levels, while others have found no samples of *B. terricola* at all, indicating possible extirpations or extremely small remnant populations (Gixti, *et al.*, 2009 at 79). The threats facing *B. terricola* are numerous and interacting. Threats including pesticide use, disease, habitat fragmentation, global climate change, small population size, and low genetic variability have all contributed to the bee's precipitous decline.

While awareness of bumble bee decline has increased, the existing regulatory mechanisms are inadequate to protect *B. terricola* and its habitat. *B. terricola* must be listed as an endangered, or alternatively as a threatened, species with designated critical habitat under the ESA to prevent the global extinction of this once common bumble bee.

Thank you for your time and attention to this Petition. We look forward to hearing from you shortly. If you have any questions or need additional information, please feel free to write or call.

Sincerely,



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