BEFORE THE SECRETARY OF THE INTERIOR

PETITION TO LIST THE VARIABLE CUCKOO BUMBLE BEE *Bombus variabilis* (Cresson 1872) UNDER THE ENDANGERED SPECIES ACT AND CONCURRENTLY DESIGNATE CRITICAL HABITAT

Variable Cuckoo Bumble Bee
(top) male side (bottom) male face
USGS Bee Inventory and Monitoring Lab
Photo by Brook Goggins

CENTER FOR BIOLOGICAL DIVERSITY

April 27th, 2021

NOTICE OF PETITION

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Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. § 1533(b); Section 553(e) of the Administrative Procedure Act, 5 U.S.C. § 553(e); and 50 C.F.R. § 424.14(a), the Center for Biological Diversity hereby petitions the Secretary of the Interior, through the United States Fish and Wildlife Service ("FWS," "Service"), to protect the variable cuckoo bumble bee (*Bombus variabilis*) under the ESA.

FWS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on the Service. Specifically, the Service must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A). FWS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id*.

Petitioner also requests that critical habitat be designated for the variable cuckoo bumble bee concurrently with the species being listed, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12.

The Center for Biological Diversity ("Center") is a nonprofit, public interest environmental organization dedicated to the protection of imperiled species and the habitat and climate they need to survive through science, policy, law, and creative media. The Center is supported by more than 1.7 million members and online activists throughout the country. The Center works to secure a future for all species, great or small, hovering on the brink of extinction. The Center submits this petition on its own behalf and on behalf of its members and staff with an interest in protecting the variable cuckoo bumble bee and its habitat.

Please contact me at 406-366-4872 or email me at jtyler@biologicaldiversity.org if you have any questions or need any clarification on the information in this petition.

Sincerely,

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Abbreviations

APHIS	Animal and Plant Health Inspection Service
BIML	Native Bee Inventory and Monitoring Lab
BLM	Bureau of Land Management
CRP	Conservation Reserve Program
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EQIP	Environmental Quality Incentive Program
ESA	Endangered Species Act
FWS	United States Fish and Wildlife Service
FLPMA	The Federal Land Policy and Management Act
GBIF	Global Biodiversity Information Facility
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
ITIS	Integrated Taxonomic Information System
IUCN	International Union for the Conservation of Nature
NEPA	National Environmental Policy Act
NFMA	National Forest Management Act
NPS	National Park Service
SGCN	Species of Greatest Conservation Need
SWAP	State Wildlife Action Plan
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
WWF	World Wildlife Fund

Suggested Citation

Tyler J. 2021. PETITION TO LIST THE VARIABLE CUCKOO BUMBLE BEE Bombus variabilis (Cresson 1872) UNDER THE ENDANGERED SPECIES ACT AND CONCURRENTLY DESIGNATE CRITICAL HABITAT. Center for Biological Diversity, Portland, Oregon.

Acknowledgements

The author would also like to thank Dr. Tara Cornelisse and Lori Ann Burd at the Center for Biological Diversity for their thoughtful review and feedback on this petition, as well as Kara Clauser, also at the Center, for making maps and conducting GIS analysis.

All bumble bee records referenced in this petition are from Dr. Leif Richardson's bumble bee database which is referred to as (Richardson 2021) in this petition.

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1. Executive Summary

The variable cuckoo bumble bee, *Bombus variabilis* (Cresson 1872), represents the starkest example of the change in North America's bumble bee community. This species has disappeared entirely from recent records with the last confirmed observation in 1999, despite increasing survey efforts. The variable cuckoo bumble bee was historically widespread throughout the eastern temperate forest region. Its range spanned the eastern half of the United States as far southwest as Arizona and as far northeast as New Hampshire.

The variable cuckoo bumble bee has a unique life history as a social parasite of the American bumble bee (*Bombus pensylvanicus* DeGeer 1773). Cuckoo bumble bees do not produce workers of their own but instead female cuckoo bumble bees take over colonies of host bumble bees. Workers from the host colonies continue to gather pollen and nectar to provision the cuckoo's larvae, producing new reproductive females and males. The variable cuckoo bumble bee is inextricably linked to the survival of its host species to the extent that females of the species no longer have the specialized pollen collecting hairs necessary to gather sufficient pollen to supply a colony. This species has never been found to reproduce in the nest of any other bumble bee species; therefore, it relies completely on the success of the American bumble bee.

This species' rarity and unique life history make it exquisitely vulnerable to changes in the population stability of its host species, the American bumble bee, which has experienced a massive change in abundance and range over the past 20 years with an 89% decline in observations, prompting a February 1, 2021 Endangered Species Act listing petition by the Center for Biological Diversity. Changes in agricultural practices over the past century introduced multiple threats to the survival and persistence of the host species. The habitat for the variable cuckoo bumble bee's host is degraded by intensive agriculture, pesticides, disease spillover, and climate change. Additionally, non-native honey bees and domesticated bumble bees introduced for honey production and pollination have spread diseases such as *Nosema bombi* to the variable cuckoo bumble bee's host.

Existing state or federal regulatory mechanisms and public land protections are inadequate to protect the variable cuckoo bumble bee and its host across the species' broad range. Public land presents little refuge as only 7% of this species' historic observations and only 4% of the host's observations have been on public lands. Even there, they face ongoing threats such as herbicide use, habitat loss, and competition and disease from honey bee apiaries. No state adequately mitigates the threats of competition and disease from domesticated bumble bees. Neither the variable cuckoo bumble nor the American bumble bee are protected under any state endangered species statute. Based on the best available science, the Fish and Wildlife Service must list the variable cuckoo bumble bee as endangered under the Endangered Species Act. The Service must act promptly to protect this species and to designate critical habitat to prevent its extinction.

2. Introduction

The health of natural ecosystems and humanity are intricately linked to the health of pollinators (Obama White House 2014 p. 1; IPBES 2016 p. 16). Animal pollination, the vast majority of which is done by bees, is required for successful production of around 90% of wild plants, 75% of leading global food crops, and 35% of the global food supply (Moisset & Buchmann 2011 p. 2; IPBES 2016 p. 16). Bumble bees are critical pollinators for crops and native plants because they are very effective pollinators for a wide variety of wild plants and crops and are capable of "buzz" pollination (De Luca & Vallejo-Marín 2013 p. 2). However, many species of bumble bees and other native bees have declined in abundance and range in North America (IPBES 2016 pp. 21–22) and are imperiled by a multitude of interacting threats that include habitat loss, agricultural intensification, pesticide use, invasive non-native species, climate change, and pathogens (Obama 2014 p. 2; IPBES 2016 pp. 24–29). Compared to pollinators who only visit specific plants or to small, solitary bees, bumble bees pollinate a large variety of plants and are capable of foraging long distances.

America's bumble bee fauna are losing ground in a continental-wide change in the makeup of the bumble bee community (Cameron et al. 2011; Bartomeus et al. 2013 pp. 662–663). Of the 46 species of bumble bees in North America, 12 are in decline and classified as vulnerable, endangered, or critically endangered according to the IUCN (Hatfield et al. 2014). Bumble bee species richness in the northeastern United States has declined by 30% in the past 140 years (Bartomeus et al. 2013 p. 4656) and one of the most complete records of bumble bee community change in Illinois found that half of all bumble bees historically found in Illinois have become extirpated or showed decline (Grixti et al. 2009 p. 81)

The Northeast and upper Midwest have lost once common species like the rusty-patched bumble bee (*Bombus affinis*) and the less common but widespread Ashton cuckoo bumble bee (*Bombus ashtoni*) which relies on the rusty-patched bumble bee as its host species. The decline of the rusty-patched and American bumble bees in the Northeast highlight the serious, widespread threats facing bumble bees. Further, in the west, rare species like Franklin's bumble bee (*Bombus franklini*) and Crotch's bumble bee (*Bombus crotchii*) are possibly extinct or declining, as are the common and widespread western bumble bee (*Bombus occidentalis*) and its obligate parasite Suckley's cuckoo bumble bee (*Bombus suckleyi*).

The variable cuckoo bumble bee is an important, generalist pollinator and represents a rare group of obligate, parasitic (cuckoo) bumble bees. Parasitic species like the variable cuckoo bumble bee are likely the most diverse species group on Earth, but are also among the most threatened and under-protected (Carlson et al. 2020 p. 2). Parasitism occurs in virtually every species, and is an important and under-valued part of the biological community (Marcogliese 2004 p. 151). There is evidence that healthy ecosystems have a high diversity of parasitic species (Hudson et al. 2006 p. 384). Parasites drive biodiversity and increase ecosystem persistence and resilience by infecting dominant species (Hudson et al. 2006 p. 383). The variable cuckoo

bumble bee is a social-parasite because it invades the nests of the host bumble bee, the American bumble bee (*Bombus pensylvanicus* DeGeer), and it relies on the hosts' workers to provision its offspring. Social parasites can maintain species diversity by decreasing competition from abundant, wide-ranging species on available floral resources. The variable cuckoo bumble bee may also play a beneficial role for its host by suppressing the host's population growth, thereby reducing the virulence of bumble bee diseases (Horwitz & Wilcox 2005 p. 728). The variable cuckoo bumble bee and other cuckoo bumble bees are especially at risk of extinction because of their dependence on the success of their host species (Suhonen et al. 2015 pp. 238–239). Without a host, the variable cuckoo bumble bee is unable to form colonies of their own to survive and reproduce because they do not produce workers and they lack sufficient pollen collecting hairs that allow females to carry large pollen loads (Suhonen et al. 2015 p. 237).

3. Natural History

3.1. Taxonomy

Bumble bees are members of the genus *Bombus* within the insect order Hymenoptera and family Apidae (Table 1). *Bombus variabilis* was first described by Ezra Townsend Cresson in 1872 (Cresson 1872 p. 284). The variable cuckoo bumble bee and all cuckoo bumble bees are classified under the subgenus *Psithyrus* (Williams et al. 2008 p. 49). *Bombus variabilis* is recognized as a valid species under the Integrated Taxonomic Information System (ITIS) (ITIS n.d. p. 1).

Any synonyms of *Bombus variabilis* are intended to also be covered by this petition. The IUCN assessment for this species considers *Apathus intrudens* (Smith 1861), *Bombus intrudens* (Smith 1861), *Bombus guatemalensis* (Cockerell 1912), *Bombus mysticus* (Frison 1925), and *Bombus sololensis* (Franklin 1913) to all be synonymous with *Bombus variabilis* (Hatfield et al. 2016 p. 2). Williams et al. (2014) consider *Bombus intrudens* to be synonymous with *Bombus variabilis* (Williams et al. 2014 p. 157). Any historic data points that have been identified with any of these designations are included in this petition as observations of *Bombus variabilis*.

Table 1. Taxonomy of *Bombus variabilis* (ITIS Report)

Kingdom	*Animalia*
Phylum	*Arthropoda*
Subphylum	*Hexapoda*
Class	*Insecta*
Subclass	*Pterygota*
Order	*Hymenoptera*
Family	*Apidae*
Genus	*Bombus*

Subgenus	*Psithyrus*
Species	*Variabilis*

3.2. Description

The variable cuckoo bumble bee is a member of the subgenus *Psithyrus* which contains all cuckoo bumble bees. This subgenus differs morphologically from other *Bombus* subgenera primarily because its females do not have corbicula or pollen-carrying baskets on their hind leg tibia. Cuckoo bees do not gather nectar or pollen for their own brood and have lost the ability to carry large amounts of pollen and nectar on their body. The variable cuckoo bumble bee produces only reproductive female and males with no worker caste.

The variable cuckoo bumble bee can be distinguished from other bumble bees based on physical characteristics and coloration. It is most similar to the lemon cuckoo bumble bee (*Bombus citrinus*) (Williams et al. 2014 pp. 163–165). Females are medium sized between 0.73 and 0.87 inches (18-22 mm) (Williams et al. 2014 p. 157). The female's body is covered in relatively short hairs that are completely black on the face with some pale hairs above the antennae, predominately black hairs on the sides of the thorax (contrast with *B. citrinus*), and with metasomal hairs (upper side of thorax) entirely black (contrast with other cuckoo bees) (Williams et al. 2014 p. 157). Males range in size from 0.58-0.67 inches (15-17 mm) with antenna of medium length (Williams et a. 2014 p. 157). The male also has relatively short hairs with black hairs on the face, black and yellow hairs interspersed in the side of the thorax (contrast *B. citrinus*), and metasoma segment T4-5 with many yellow hairs (contrast *B. citrinus*) (Williams et al. 2014 p. 157).

3.3. Life Cycle and Behavior

The variable cuckoo bumble bee is a social parasite of the American bumble bee. The major difference between members of the subgenus *Psithyrus* (cuckoo bumble bees) and other *Bombus* species is that all individual variable cuckoo bumble bees can reproduce, and they produce no sterile worker caste. Cuckoo bumble bees survive by invading the nest of other bumble bees and killing or subduing the resident queen and taking control of the workers of the invaded colony and relying on them to gather nectar and pollen for the cuckoo bee's offspring. A female cuckoo bumble bee is not strictly speaking a queen because she does not produce any worker bees of her own. Cuckoo bumble bees life cycle is so dependent on their host species for survival they have lost the ability to collect sufficient pollen and nectar to produce colonies of their own (Goulson 2010 p. 77). The variable cuckoo bumble bee relies only on the American bumble bee as its host species and was first reported in the nest of the American bumble bee in 1910 by Frison (Frison 1916 p. 47). This species has only been found to breed in American bumble bee nests (Williams et al. 2014 p. 158).

The variable cuckoo bumble bee has an annual life cycle that begins in the spring. Mated females emerge later in the spring than the host species and forage until they find a suitable host colony to invade. The cuckoo female invades the host colony early in the colony cycle when it reaches sufficient size and kill or subdues the host queen. The variable cuckoo bumble bee female produces male and female offspring that are fed and cared for by the host workers and once developed, individuals leave the nest. After mating, the males die, and the mated females feed on nectar and pollen prior to overwintering (Goulson 2010 p. 12) and starting the cycle over in the spring.

3.4. Habitat

The variable cuckoo bumble bee inhabits the same open areas of its host species the American bumble bee in the eastern temperate forest and Great Plains region of the United States with scattered occurrences in the southeastern coastal plain, southern Texas, and southern Arizona (Williams et al. 2014 p. 157). Example food plants for the variable cuckoo bumble bee include aster family, *bidens*, *echinacea, helianthus*, and *solidago* (Williams et al. 2014 p. 158). The variable cuckoo bumble bee requires suitable nesting sites for their host's colony, nectar and pollen resources during the colony period (spring, summer, and fall), and suitable overwintering sites for mated females (Goulson 2010 pp. 5–12).

Suitable open meadows with sufficient nectar, pollen, and nesting sites often exist within patchy meadow-complexes and bumble bees are able to exploit scattered resources because they are highly mobile compared to other insects (Hatfield & LeBuhn 2007 pp. 154, 156). Quality and quantity of bumble bee habitat varies at a landscape scale and bumble bees routinely forage over relatively large distances of > 1.25 miles (> 2000 m) (Hatfield & LeBuhn 2007 p. 151) and require approximately 815-2500 acres (329-1011 hectares) of suitable habitat to sustain viable populations (Goulson 2010 p. 193). The percentage of grasslands, especially native prairie remnants, within 0.3 mi (500 m) of a nest is an important predictor of bumble bee diversity (Hines & Hendrix 2005 p. 1481). The temporal distribution of flowering plants is also important, as the amount of nectar and pollen during the early spring and late summer impact the growth of the host colony and for the production of variable cuckoo bumble bee individuals (Westphal et al. 2009 p. 192; Goulson 2010 pp. 208–210).

The variable cuckoo bumble bee relies exclusively on the American bumble bee as its host species; therefore, the habitat preferences of the American bumble bee are immediately relevant to the conservation of this species. Specific habitat requirements for the American bumble bee have only been studied in-depth in southern Ontario, Canada, the northern edge of its range. There, the American bumble bee's habitat is associated with floral and landscape characteristics of open land mixed with some forest (Liczner & Colla 2020 p. 6). The American bumble bee is associated with plants generally found in open or disturbed habitats including: creeping bluet, marsh marigold, and yellow rocketcress in the spring; wood lily, dames rocket, and white clover in the summer; and crownvetch, knapweed, and Canadian tick trefoil in the

late-summer (Liczner & Colla 2020 p. 6). Besides flowers, the American bumble bee's habitat varies by the season and is associated with coarse woody debris, rodent burrows, and a lower native to non-native flowering plant species ratio (compared to *Bombus terricola*) (Liczner & Colla 2020 p. 6).

The American bumble bee have been found to nest in grasslands and open farmland, mostly on the surface of the ground among tall grass, but occasionally underground (Williams et al. 2014 p. 149). In general, bumble bees are considered opportunistic nesters that will take advantage of pre-existing holes and depressions below the surface formed by rodents or cavities above the surface created by old logs, stumps, old ground-nesting bird nests, or clumps of grass (Schweitzer et al. 2012 p. 10). The variable cuckoo bumble bee females also require sites where they can hibernate during the winter after mating. The specific requirements of overwintering nest sites of the variable cuckoo bee females are not yet known, but bumble bees are generally known to hibernate close to the ground surface or down an inch or two in loose soil, or under leaf litter or other debris, in sites that are undisturbed and have adequate organic material to provide shelter (Williams et al. 2014 p. 15).

4. Historic and Current Distribution

The variable cuckoo bumble bee has suffered nothing short of a catastrophic decline in abundance and range (Figure 1). The best available records indicate that there have been no observations of the variable cuckoo bumble bee since 1999 (Figure 1) (Richardson 2021, personal communication) which indicates a collapse of the populations across its 28-state range. This species has experienced a 100% decline in observations and range over the past approximately 80 years (Figure 1). The alarming IUCN assessments of the decline of the variable cuckoo bumble bee also concludes that the variable cuckoo bumble bee is critically endangered and has (conservatively) experienced a 80% decline overall with a 100% decline in abundance (Hatfield et al. 2016 p. 4). These conclusions are based on the bumble bee database created by Dr. Leif Richardson who has assembled a database of more than 519,000 bumble bee records that is generally considered to be the most comprehensive collection of *Bombus* records in the United States.

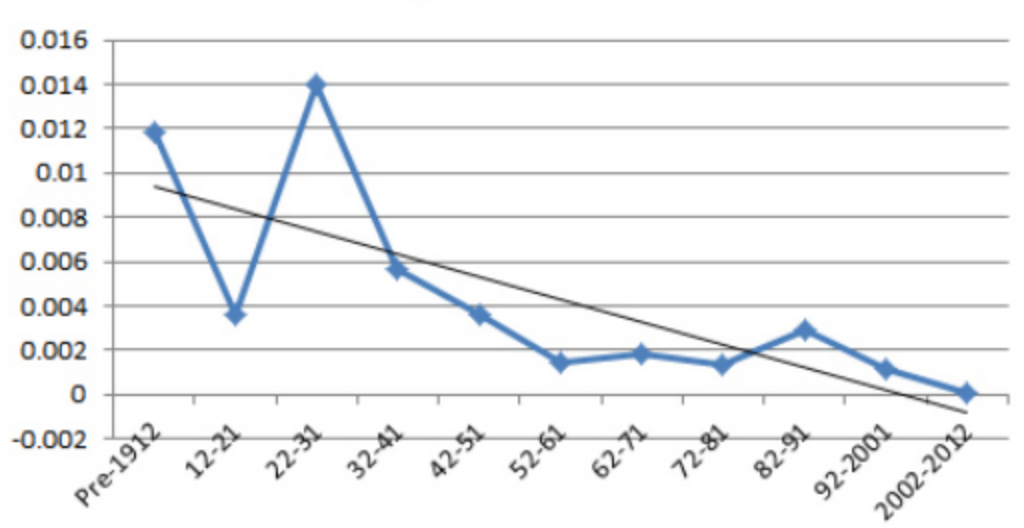

Figure 1. Relative abundance of the variable cuckoo bumble bee as a fraction of all bumble bee observations from >100 years of available records. Taken from Hatfield et al. (2016 supplemental material).

The variable cuckoo bumble bee historically occupied the eastern temperate forest and Great Plains regions of the Midwest with scattered observations along the southeastern coastal plain, southern Texas, and southern Arizona (Williams et al. 2014 p. 157). There are historic records of the variable cuckoo bumble bee in 28 states as far west as Arizona and as far east as New Hampshire (Figure 2). The states with the largest number of observations include Illinois, Indiana, Kansas, Florida, and Texas (Table 2).

The variable cuckoo bumble bee was one of the rarest bumble bees in North America (Williams et al. 2014 p. 157) representing ~1% of all bumble bee observations at its highest level in the 1920s (Figure 1). From the 1940s onward, the variable cuckoo bumble bee has declined steadily through the middle of the 20th century in terms of the number of total observations and in the relative number of observations compared to all bumble bee records (Figure 1).

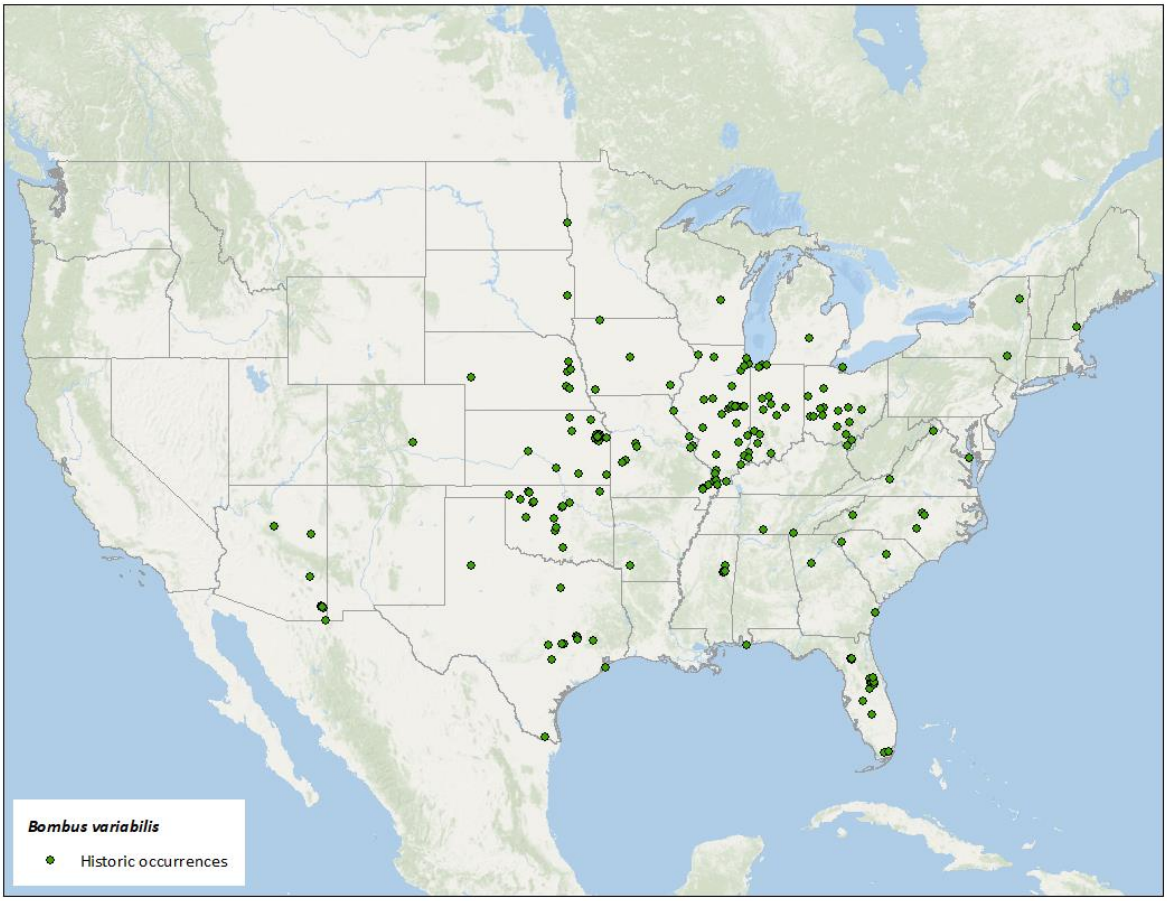

Figure 2. Historic (1999 and earlier) records of the variable cuckoo bumble bee.

Table 2. Number of historic records and conservation status by state of the variable cuckoo bumble bee in the United States based on physical specimens and observation records from many databases and public and private collections (Richardson 2021).

State	Number of Historic Records (1896-2001) (last year observed)	State Conservation Status
Alabama	2 (1991)	
Arizona	20 (1989)	
Arkansas	2 (1948)	
Colorado	2 (1980)	
Florida	82 (1995)	Species of Greatest Conservation Need
Georgia	5 (1992)	
Illinois	547 (1980)	Invertebrate Species Watch-List
Indiana	120 (1969)	
Iowa	10 (1962)	

Kansas	133 (1990)	
Louisiana	1 (1906)	
Maryland	1 (1970)	Species of Greatest Conservation Need
Michigan	2 (1960)	
Mississippi	14 (1995)	
Missouri	17 (1999)	
Nebraska	24 (1999)	Species of Greatest Conservation Need Tier 2
New Hampshire	2 (1929)	
New York	2 (1914)	
North Carolina	45 (1957)	
North Dakota	1 (1916)	
Ohio	42 (1960)	
Oklahoma	39 (1975)	Species of Greatest Conservation Need
South Carolina	4 (1959)	
South Dakota	1 (1958)	
Tennessee	4 (1993)	
Texas	51 (1992)	
Virginia	6 (1978)	Virginia DCR List of Rare Animals
Wisconsin	3 (1930)	
Total	**1182 (1999)**	

The most recent observations of the variable cuckoo bumble bee from 1995, 1998, and 1999 represent 17 observations from Florida (Orange county, one site), four observations in Mississippi (Oktibbeha and Clay counties), four observations in Nebraska (Lancaster and Dodge county), and three observations from Missouri (Scott and St. Clair county) (Table 3). The variable cuckoo bumble bee was previously found in a variety of habitat types including urban areas (North Bend, Lincoln Nebraska. and on the University of Central Florida campus), within an agricultural matrix in Nebraska and Missouri, and in protected land within the Sam D. Hamilton Noxubee National Wildlife Refuge. This habitat variability is reflective of the adaptable nature of its host species.

Table 3. The most recent observations of the variable cuckoo bumble bee from 1995-1999.

State (county)	Last observation(s) year
Nebraska (Dodge)	1999
Nebraska (Lancaster)	1999
Missouri (Scott)	1998
Missouri (St. Clair)	1998
Florida (Orange)	1995
Mississippi (Clay)	1995
Mississippi (Oktibbeha)	1995

Since the time of the last confirmed sighting of the variable cuckoo bumble bee in 1999, one of the most complete records of bumble bee community change in Illinois produced no records of the variable cuckoo bumble bee in Illinois (Grixti et al. 2009 p. 80) which was previously the state with the largest number of historic variable cuckoo bumble bee observations (Table 2) (Richardson 2021). This study referenced 56 sites in Illinois and compared historic records from 1900 to recent surveys in 2007 (Grixti et al. 2009 p. 80). Beyond Illinois, this species has not been found in any bumble bee survey in the past 20 years despite recent survey effort across the country that has led to the completion of the first nationwide bumble bee survey published in Koch et al. (2015). Entomologists and researchers from numerous institutions contributed more than 17,000 bumble bee observations from 2007 to 2010 to this effort. Based on this enormous survey effort, Cameron et al. (2011) compared over 16,000 bumble bee observations to more than 73,000 historical bumble bee specimens and revealed a complete collapse of the variable cuckoo bumble bee's range and that its host, the American bumble bee's, range has decreased by 23% (Cameron et al., 2011 p. 664).

Regional and national survey effort from 2012-2020 has verified the population collapse of the variable cuckoo bumble bee. Numerous studies, as presented below, have failed to document the variable cuckoo bumble bee and have shown the continued decline of the American bumble bee (See Table 4 for a list of published surveys from 2012 to 2020).

Table 4. Recent survey effort for bumble bees across the range of the variable cuckoo bumble bee.

Author	State	Extent
Tripodi and Szalanski 2015	Arkansas	Statewide
Kearns et al. 2017	Colorado	Boulder County
Hughes 2018	Illinois	Midewin National Tallgrass Prairie
Geroff et al 2014	Illinois	Western Illinois University, Life Science Station
Bee Spotter 2007-2020	Illinois, Iowa, Indiana, Ohio, Missouri,	Regional

	Virginia, Michigan, Wisconsin, Maryland	
Arduser 2015	Iowa, Illinois, Minnesota, Missouri, Wisconsin	Nine National Wildlife Refuges
Selfridge et al. 2017	Maryland	Worchester County, 30 forested dune study sites
Kammerer et al. 2020	Maryland, Delaware, District of Columbia	Statewide
Evans et al 2019	Minnesota	Twin Cities Metro Area
Otto et al. 2020	Minnesota, North Dakota, South Dakota	Private CRP and EQIP land
Smith et al 2012	Mississippi	Black belt prairie in Chickasaw, Oktibbeha, and Lowndes County
Camilo et al. 2017	Missouri	St. Louis
Jacobson et al. 2018	New Hampshire	Statewide
Ascher et al 2014	New York	Gardiner's Island, Suffolk County
Figueroa and Bergey 2015	Oklahoma	Statewide
Beckham and Atkinson 2017	Texas	Statewide
Hands on the Land.org 2015	Virginia and North Carolina	Blue Ridge Parkway
Prince 2016	Wisconsin	Portage, Waushara, and Adama Counties
Xerces Society Bumble Bee Watch	Nationwide	Nationwide

5. Warranted ESA Protection

The ESA is a "comprehensive scheme with the 'broad purpose' of protecting endangered and threatened species." Ctr. for Biological Diversity v. U.S. Bureau of Land Mgmt., 698 F.3d 1101, 1106 (9th Cir. 2012) (quoting Babbitt v. Sweet Home, 515 U.S. 687, 698 (1995)). Congress' plain intent in enacting the ESA was "to halt and reverse the trend toward species extinction." Tenn. Valley Auth. v. Hill, 437 U.S. 153, 184 (1978). In pursuit of this purpose, the ESA requires that "all Federal departments and agencies shall seek to conserve endangered species and threatened species and shall utilize their authorities in furtherance of [these]

purposes." 16 U.S.C. § 1531(c)(1) (emphasis added). Endangered and threatened species are "afforded the highest of priorities" Tenn. Valley Auth., 437 U.S. at 174. "Endangered species" are species that are "in danger of extinction throughout all or a significant portion of its range," and "threatened species" are species that are "likely to become endangered species within the foreseeable future" throughout all or a significant portion of range. 16 U.S.C. § 1532(6), (20). The ESA states that a species shall be determined to be endangered or threatened based on any one of five factors: 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 2) overutilization for commercial, recreational, scientific, or educational purposes; 3) disease or predation; 4) the inadequacy of existing regulatory mechanisms; and 5) other natural or manmade factors affecting its continued existence. Id. § 1533(a)(1).

The variable cuckoo bumble bee warrants protection under the ESA. The population of the species has catastrophically declined across its entire range with no observation since 1999. The variable cuckoo bumble bee's imperilment is known to be caused by listing factors one, three, four and five. Loss of the host species, the American bumble bee, is the primary, direct threat to the survival of the variable cuckoo bumble bee. As a parasite, the variable cuckoo is entirely dependent upon the American bumble bee to establish nests and produce workers that enable the variable cuckoo bumble bee to reproduce and sustain a viable population. On top of the loss of the American bumble bee, multiple, concurrent threats including intensive agriculture, pathogen spillover, climate change, and small population dynamics degrade the habitat quality and compromise the health of the variable cuckoo bumble bee and the American bumble bee (see Section 6 for a detailed threat assessment). Land conversion to intensive agriculture and other uses that deplete and degrade wild flowering plants have reduced the habitat value of agricultural land. Pesticide use on agricultural land harms bumble bees directly by exposure to these poisons and indirectly by degrading habitat and weakening bumble bee immune systems (Goulson et al. 2015 p. 6). Insecticides like neonicotinoids and numerous fungicides are very harmful to bumble bees but face few regulatory hurdles that would protect bumble bees and, in general, show no signs of losing popularity among farmers. Domesticated bumble bees and honey bees also continue to introduce pathogens to American bumble bee populations with no recent movement at the state or federal level to address disease spread and spillover. These factors and others have reduced the populations of the variable cuckoo bumble bee over time and are compounded by a lack of regulation and targeted conservation effort across the species range. None of these threats are temporary and all will remain a threat for the future. The variable cuckoo bumble bee needs ESA protection to respond to the nationwide scale of the threats and to coordinate effective conservation support.

6. Current and Potential Threats

6.1. Loss of host species

The decline of the variable cuckoo bumble bee is inherently linked to the decline of its host species, the American bumble bee. Losing the American bumble bee spells extinction for

the variable cuckoo because it has only been documented breeding in nests of the American bumble bee (Williams et al. 2014 p. 158) which limits the adaptability and survival of the variable cuckoo bumble because it may not be able to transfer to another host species (Suhonen et al. 2019 p. 10). The variable cuckoo bumble bee is more at risk of extinction than other rare bumble bees because it is a social parasite dependent on a host species (Suhonen et al. 2015 pp. 238–239). The variable cuckoo bumble bee relies so heavily on its host species because they lack special pollen collecting hairs and do not produce workers (Suhonen et al. 2015 p. 237) so they are unable to form colonies of their own to survive and reproduce in the absence of the host species. Cuckoo bumble bees also exist in smaller populations than their host species and thus have limited genetic variation, an increased risk of inbreeding, and reduced resistance to diseases (Suhonen et al. 2015 p. 238).

The American bumble bee was among the most common, dominant species in North American and has seen a devastating loss in relative abundance and range losing the northern part of its range as well as losing range in the Southwest (Figure 4). The American bumble bee exists at only 11% of its historic relative abundance and its current range has contracted by 19% according to the IUCN assessment (Figure 3) (Hatfield et al. 2015 p. 4). This species has recently been petitioned for protection under the ESA because of its steep, widespread decline (Tyler & Bombus Pollinators Association of Law Students 2021 entire).

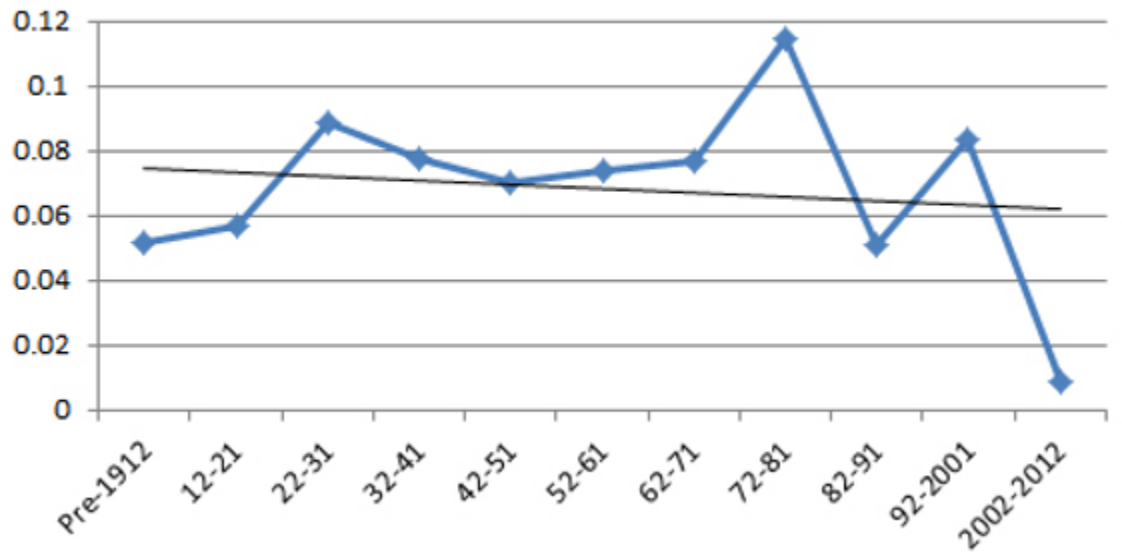

Figure 3. Relative abundance of the American bumble bee as a faction of all bumble bee observations from over >100 years of available records. Taken from Hatfield et al. (2015 supplemental material).

The American bumble bee has been observed in all of the lower 48 United States, except Washington, but it has seen declines in states where it was historically abundant and has nearly disappeared from northern states where it was historically rare. The number of recent observations in the Northeast and Northwest have been reduced to zero or near zero in several

states including: Oregon, Idaho, Montana, Wyoming, Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. A total of 16 northwestern, northeastern, and midwestern states have seen declines of >90%, which meets the IUCN criteria (IUCN 2019 p. 16) for critically endangered: Connecticut, Delaware, Idaho, Maine, Massachusetts, Michigan, New Hampshire, North Dakota, New York, Oregon, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wyoming (Figure 4) (Richardson 2021). Even more alarming, the American bumble bee has seen large declines in states with large amounts of once suitable habitat where it was once abundant such as Arkansas (72% decline), Georgia (74% decline), and Illinois (69% decline) (Richardson 2021). Currently, 11 States have seen a relative decline of >70% which meets the IUCN criteria (IUCN 2019 p. 16) for Endangered: Georgia, Illinois, Indiana, Maryland, Minnesota, Nebraska, New Jersey, Ohio, South Dakota, Virginia, and Wisconsin (Figure 4) (Richardson 2021). And eight mostly Midwestern States have seen declines of >50% which meets IUCN criteria for Vulnerable: Arkansas, Iowa, Kansas, Mississippi, Missouri, North Carolina, New Mexico, and Tennessee (Richardson 2021).

The population of the American bumble bee will continue to decline in the coming decades without ESA listing to protect the species (Tyler & Bombus Pollinators Association of Law Students 2021 p. 18). The rate of decline (Figure 3) over the past decade has been very steep as this species moved past a tipping point around the year 2000. Populations of declining species often continue to decline slowly after an initially sharp decline until they recover. The rusty-patched bumble bee was projected to decline in the Species Status Assessment (Szymanski et al. 2016 Figure 7.3) for years after it was petitioned in 2013 and recent data indicates that it has continued to decline after 2013 (Richardson 2021). Therefore, it is unlikely that we have seen the full decline of the American bumble bee which presents dire implications for the recovery of the variable cuckoo bumble bee.

Additionally, the American bumble bee has been shown to have lower genetic diversity compared to other bumble bees (Lozier & Cameron 2009 p. 1882) which increases the threat of inbreeding depression for this species which further threatens the variable cuckoo bumble bee. Genetic study of American bumble bees in Illinois showed that the species has experienced significant genetic change and a consistent decline in genetic diversity (Lozier & Cameron 2009. p. 1882). Because of a declining population, American bumble bee populations have become increasingly isolated over the last four decades in its historical range (Lozier & Cameron 2009 p. 1881). As American bumble bee populations become further isolated, it is less likely it is that the current populations will be able to recover from current threats to support populations of the variable cuckoo bumble bee.

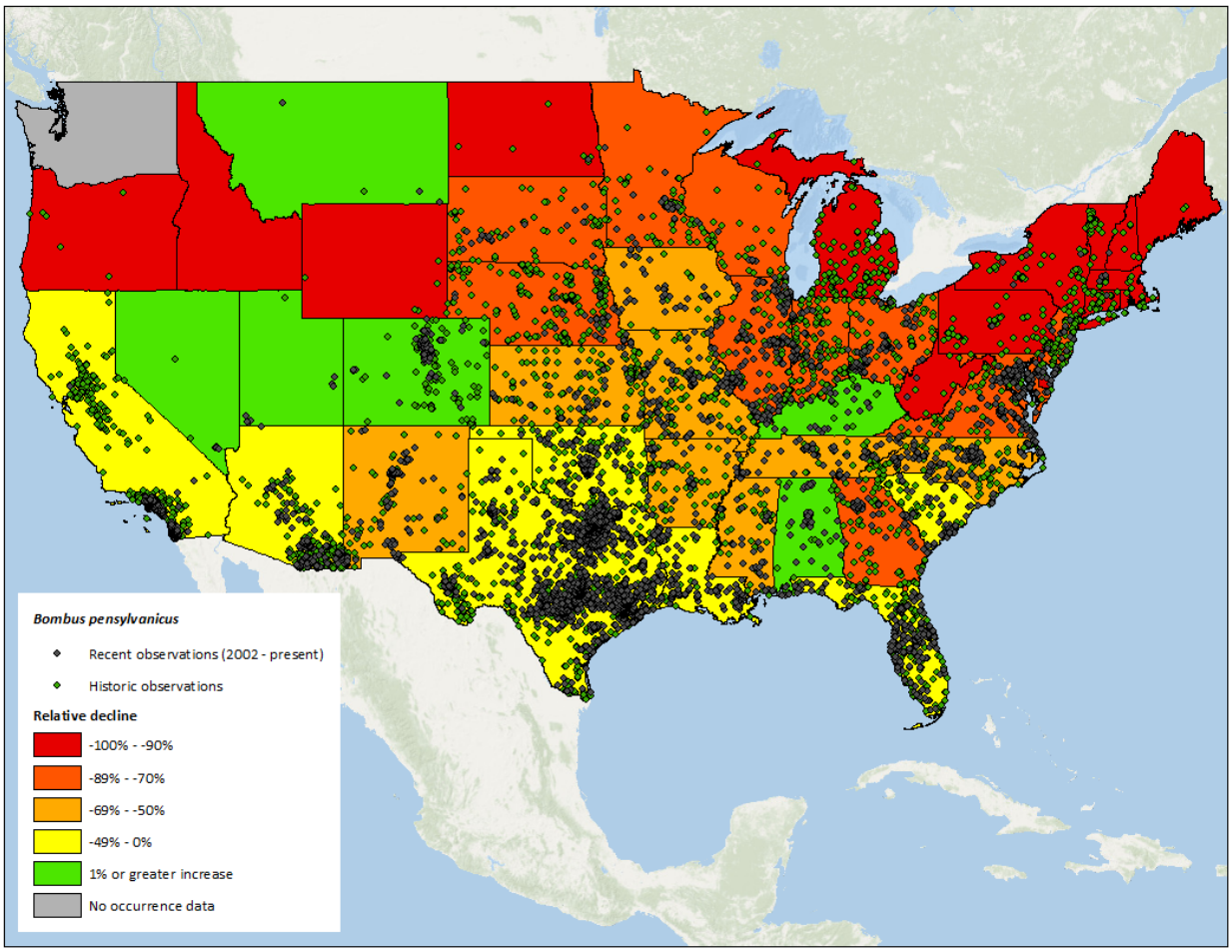

Figure 4. Decline in relative abundance of the American bumble bee with historic and recent observations. The change for each state represents the relative decline or gain of relative abundance from historic relative abundance to recent relative abundance. The recent period is 2002-2020.

6.2. Habitat Loss and Degradation

Landscape changes that destroy or modify the presence of diverse flora, nesting, and overwintering sites are detrimental to the survival of the variable cuckoo bumble bee. Habitat loss and fragmentation is the number one driver of insect declines worldwide (Sánchez-Bayo & Wyckhuys 2019 p. 19). The variable cuckoo bumble bee and its host have lost habitat through the destruction, fragmentation, and modification of habitat by intensive agriculture, livestock grazing, and widespread pesticide use that limits access to floral resources, lowers floral richness, and limits nesting sites across its range (Darvill et al. 2006 pp. 608–609; Grixti et al. 2009 p. 81; Goulson 2010 pp. 181–186; Szabo et al. 2012 p. 81). Declining habitat for the host species is a critical threat to the variable cuckoo bumble bee and will be emphasized in this section.

Habitat loss directly reduces the amount of nectar and pollen available and, more than anything else, floral resources are the most important factor affecting the presence of the American bumble bee (Liczner & Colla 2020 p. 6). Bumble bee colonies that are food limited

simply grow less, especially when the limitation is in the early spring (Rotheray et al. 2017 p. 18). Inadequate nutrition significantly affects the survival of reproductive female bumble bees and is most important in the first few days as emerged adults in the late summer as well as in the early spring post-diapause (Woodard et al. 2019 pp. 6–7). Food limitation also reduces the number of males produced (Rotheray et al. 2017 p. 18).

The variable cuckoo bumble bee and the American bumble bee rely on open farmland and field habitat (Williams et al. 2014 p. 149). Open-field habitat has seen an enormous disturbance over 150 years of westward expansion in America by European settlers. It is not practical to outline the changes to the many possible habitat types for the American bumble bee, but present, substantial threats to current open-field habitat remain across its range. Temperate grasslands make up a large portion of American bumble bee habitat, but they are among the least protected and most impacted of all biomes where habitat conversion exceeds habitat protection by a factor of 10 to 1 (Hoekstra et al. 2005 p. 25). Temperate grasslands including native prairie ecosystems has declined by up to 99.9% (Samson & Knopf 1994 p. 418; Noss et al. 1996 Appendix A and B). Native, biodiversity-rich grasslands, that are not destroyed completely are often replaced with open-fields that consist primarily of introduced grasses or monoculture forage crops that are generally less suitable to bumble bees (Black et al. 2011 p. 9). Urban land expansion is also expected to more than double in area by 2050 (Nowak & Walton 2005 p. 385; Huang et al. 2019 p. 3) and is a threat to open-field land when farmland or semi-natural areas are replaced with roads or other uses that diminish floral and nesting resources.

States all around the country are losing perennial grassland[1] that previously supported the variable cuckoo bumble bee and its host. Perennial grassland is being lost for a variety of factors including, forest encroachment, urbanization, conversion to row crops, and other uses which puts increasing pressure on the remaining perennial grasslands. States across the Midwest and the Northeast have lost as much as 50% of their perennial grasslands and now have very few or no recent observations of the American bumble bee (USDA 2018 Table 2; Richardson 2021). Illinois, Indiana, and Michigan have all lost large amounts of their perennial grasslands (30%, 20%, and 25%, respectively) in addition to other states like Ohio, Florida, Oklahoma, and Kansas that have also lost 24%, 14%, 8%, and 5% respectively of their potential habitat for the variable cuckoo bumble bee and its host (USDA 2018b Table 2).

These are just some of the broad scale changes that presently threaten open, field habitat for the variable cuckoo bumble bee. The threats outlined in this section apply to both the variable

[1] Perennial grassland refers to all open land (non-forested pastureland and rangeland) that is not used for row crops regardless of its species composition. Data cited here refers to the NRCS Natural Resource Inventory which quantifies “pastureland” and “rangeland”. “Pastureland” refers to land managed primarily for the production of introduced forage plants for livestock grazing (USDA 2018 p. 4-1). “Rangeland” refers to land on which the climax or potential plant cover is composed principally of native grasses, grass-like plants, forbs or shrubs suitable for grazing and browsing, and introduced forage species that are managed like rangeland (USDA 2018 p. 3-2).

cuckoo bumble bee and the American bumble bee. Specific threats from agricultural intensification, livestock, and pesticide use are outlined in more detail below.

6.2.1. Agricultural Intensification

Modern, intensive agriculture has accelerated the fragmentation and degradation of habitat for the variable cuckoo bumble bee (Schweitzer et al. 2012 pp. 7–8). Changes in agricultural practices and continued expansion occurred primarily between 1940 and 1960 and contributed to broad declines in bumble bee species richness (Grixti et al. 2009 p. 81). This period coincides with the steady decline of the variable cuckoo bumble bee (Figure 1). The transition to intensive agriculture has led to vast monoculture crop systems that rely on much higher inputs of fertilizer and pesticide (Goulson 2020 p. 1) which destroy and degrade field margin habitat that bumble bees rely on for food and nesting habitat (Hines & Hendrix 2005 p. 1483).

Agriculture continues to expand and intensify as many farmers in the great plains continue to plow prairie and grassland at a rate of four football fields per minute to expand the production of corn, soy, wheat (World Wildlife Fund 2020 p. 1). Expanding, intensive agriculture removes and degrades floral resources along field margins that are essential to the survival of the variable cuckoo bumble bee. Floral rich margins and hedgerows are incredibly important to the persistence of common bumble bees like the American bumble bee because we know that restoring pollinator habitat with hedgerows, roadside plantings, and wildflower strips are effective for conserving species like the American bumble bee (Kleijn et al. 2015 p. 4). By destroying field margin habitat in pursuit of larger fields with higher yield, modern agriculture has become reliant on pesticides, and the amount of pesticide has a demonstrable negative relationship to populations of the American bumble bee (Szabo et al. 2012 p. 236). Overall, the variable cuckoo bumble bee and its host are being driven out of agricultural areas where they previously thrived because of the loss and poisoning of field margin habitat.

6.2.2. Livestock Grazing

Ruminants

Livestock production has intensified in recent decades which puts more pressure on landscapes, directly and indirectly harming the variable cuckoo bumble bee, its host, and other native pollinators. Between 1982 and 2015 the United States lost ~23.5 million acres of land for grazing (USDA 2018a pp. 3-46), primarily to crop production and development, yet beef production increased from 39.7 million pounds in 1988 to 44.8 million pounds in 2019 (U.S. Department of Agriculture 2020). All cows begin their lives on pasture, and America is producing more meat on fewer acres, which has led to soil erosion, loss of biologic integrity, invasive species, and general degradation (Fleischner 1994 p. 631; Belsky et al. 1999 entire). Open habitat suitable for grazing livestock can be quite suitable habitat for the American bumble

bee, but this land continues to become more degraded around the country (USDA 2018b pp. 4–5).

Grazing has a negative impact on abundance and richness of the bee community in both exotic and native grass communities (Campbell et al. 2021 p. 1). Domestic grazing animals can harm bumble bees by trampling soil, removing floral resources, and degrading bumble bee habitat (Hatfield & LeBuhn 2007 p. 153; Yoshihara et al. 2008 p. 2384) which can lead to a linear decline in bee abundance and richness (Yoshihara et al. 2008 p. 2384; Tadey 2015 p. 455; Lázaro et al. 2016 p. 408). Grazing livestock have considerable, adverse effects on grassland ecosystems by altering plant species composition and reducing flowering forb species diversity (Fleischner 1994 p. 631; Black et al. 2011 p. 10). Overstocking and heavy grazing, especially during the spring and summer, reduces the amount of floral resources and degrades grassland habitat for bumble bees (Goulson 2010 pp. 210–211). In addition, grazing animals cause soil compaction which negatively affects the American bumble bee's ability to find shelter in abandoned rodent holes or develop new nest sites that are not at risk of being trampled (Black et al. 2011 p. 10; Kimoto et al. 2012 p. p.7-8; Bueno et al. 2012 pp. 5–6). Pastures and fields consistently cut short for hay also severely affects the survival of surface nests (Williams & Osborne 2009 p. 372).

Non-native honey bees and exploitative competition

The honey bee (*Apis mellifera*) harms the variable cuckoo bumble bee by direct competition and by transmitting disease (Mallinger et al. 2017 pp. 24–25). Honey bee competition affects native bees by depleting pollen and nectar (Torné-Noguera et al. 2016 p. 14), reducing fecundity (Paini & Roberts 2005 pp. 107–108), enhancing parasitism (Goodell 2003 p. 13), floral host preemption (Roubik & Villanueva-Gutiérrez 2009 p. 156), reducing foraging success (Henry & Rodet 2018 p. 2), and pathogen spillover (Fürst et al. 2014 pp. 3–4). As a prime example, the western bumble bee, which has declined by >90% (Graves et al. 2020 p. 7), had lower foraging success and reduced reproductive success when near honey bee hives (Thomson 2004 pp. 463–464). Honey bees have a negative competitive effect on bumble bees specifically and result in lowered reproductive success (Thomson 2004 pp. 463–464), changes in bumble bee foraging behavior (Elbgami et al. 2014 p. 508), lowered average bumble bee body size (Goulson & Sparrow 2009 pp. 7–8), and causing pathogen spillover (Fürst et al. 2014 pp. 3–4).

Honey bee colonies support more individual bees than any other social bee and are able to outcompete native bees for nectar and pollen resources on the landscape because they are active for longer and have the ability to recruit nest mates to floral resources (Cane & Tepedino 2016 p. 206). A single honey bee colony can consume 44lbs (20kg) of pollen and nectar over the course of a foraging season (Cane & Tepedino 2016 p. 206). A small 40 hive commercial apiary removes enough nectar and pollen in three months from an area that could provision 4,000,000 native bees (Cane & Tepedino 2016 p. 207).

The upper Midwest, where the variable cuckoo bumble bee's host has seen a disastrous decline (Figure 4), hosts more than 40% of the honey bee hives in the country and is considered by beekeepers to be "America's last beekeeping refuge" because it provides valuable summer pasture with high-quality grasslands and large amounts of conservation areas like Conservation Reserve Program (CRP) lands. Pesticides can still be an issue on CRP but are not as significant of a problem as on cultivated cropland and field margins (U.S. Geological Survey 2019 p. 1). North Dakota and South Dakota are the largest honey producing states in the country (U.S. Geological Survey 2019 p. 2), but the variable cuckoo may be extirpated from North Dakota and South Dakota (Richardson 2021).

The USGS conducted the largest survey of grasslands in the upper Midwest to evaluate forage for honey bees and they found that honey bees far outnumbered native bees on conservation lands (Otto et al. 2020 p. 17). Otto et al. (2020 pp. 15-17) surveyed more than 1300 transects on private lands enrolled in CRP and Environmental Quality Incentives Program (EQIP) in Minnesota, North Dakota, and South Dakota in 2015-2017 and observed 1,740 honey bees, but only 175 wild bees including a mere 36 bumble bees. Neither the variable cuckoo nor the American bumble bee were present in North Dakota or South Dakota (Otto et al. 2020 supplemental data). This survey indicates that honey bee competition for floral resources depresses the number of native bees in places that are intended to be reserves for wildlife.

Honey bee hives on public land also represent a significant threat to bumble bees and other native bees. The USFS permits apiaries across every forest region in the country, which increases competition for resources, enhances disease spread, and jeopardizes the reproduction of native plants (Grand Canyon Trust et al. 2020 entire). In the Colorado Plateau, permits of honey bees on national forest land could place as many as 56.8 million bees on public lands which present major competition for limited floral resources (Grand Canyon Trust et al. 2020 p. 3). Public lands represent a small portion of both the variable cuckoo bumble bee and the American bumble bee's range but permitting large numbers of hives on public land reduces resources and increases disease risk for the variable cuckoo bumble bee and the American bumble bee.

Commercial bumble bees

Commercial bumble bees, particularly the eastern bumble bee (*Bombus impatiens*), compete with and bring diseases to wild bumble bees (IUCN Bumble bee specialist group 2019 p. 1). Domesticated bumble bees are currently used in greenhouses and in open field settings to provide crop pollination services. The large sizes, high densities, and transportation of managed bumble bee populations makes domesticated bumble bees a serious threat for pathogen transmission to wild bees (Velthuis & Van Doorn 2006 p. 12) (see threats section 6.3.1 for details about pathogen spillover). While the variable cuckoo bumble bee does not rely on the eastern bumble bee as a host species, the eastern bumble bee is becoming more commonly used for crop pollination and it will provide a significant source of disease and competition (Velthuis & Van Doorn 2006 p. 432) to the variable cuckoo bumble bee and its host.

6.2.3. Pesticide Use

Pesticide use threatens the variable cuckoo bumble bee with direct poisoning, sublethal effects, habitat degradation, and presents a secondary threat because it impairs the survival of the American bumble bee (Tyler & Bombus Pollinators Association of Law Students 2021 pp. 40–46). Pesticides affect bumble bees that forage in and around agricultural lands, in landscaped areas, in pesticide treated forests and rangelands, along roadsides and other rights of way, and in a wide array of other areas. Pesticide use has been cited as a major contributor to the decline of bumble bee populations across North America and Europe (Goulson et al. 2008 pp. 194–195; Cameron & Sadd 2020 p. 2).

Bumble bee exposure to pesticides occurs in a variety of ways including: direct contact with spray drift, orally when residues are present in nectar or pollen, and through contact with contaminated soil (Fischer & Moriarty 2014 pp. 53–54). Nectar uptake is likely the main source of exposure and poses the largest threat because bumble bees consume large quantities of nectar and pesticides accumulate in high concentrations in nectar (Goulson et al. 2008 p. 194). Bumble bees are also exposed to pesticides via the soil from treated seeds and over-the-top applications that contaminate bumble bee underground nests and overwintering sites (Hopwood et al. 2016 pp. 14–15). Pesticide contamination can also occur through water sources on and around plants that bees rely on during foraging (Lu et al. 2020 p. 4). Pesticide exposure during the spring is especially harmful to the variable cuckoo bumble bee because the overwintered females forage for themselves during this time before they invade a host colony and exposure to reproductive members has greater consequence for a species population (Goulson et al. 2008 p. 194).

The increased use of pesticides in agricultural and urban settings exposes bumble bees to a pesticide “cocktail” including fungicides, herbicides, and insecticides. The EPA does not consider the impacts of pesticide mixtures and potential synergistic effects in its pesticide regulatory process, but independent studies have shown that pesticide mixtures can create more potent toxic effects (Goulson et al. 2015 p. 1). These experimental chemical cocktails, found in most non-protected landscapes, contaminate pollen, wax, brood, and adult honey bees with as many as 120 different pesticides (Mullin et al. 2010 p. 3) and as many as 60% of bumble bees have detectable levels of at least one pesticide (Botías et al. 2017 p. 7). There is still much to be learned about pesticide synergistic effects, but we know that the combination of pesticides can have a range of effects even at low realistic doses (Almasri et al. 2020 p. 6). As an example, we know that when commonly used ergosterol biosynthesis inhibitor fungicides are mixed with other commonly used neonicotinoids and pyrethroids, the toxicity of the mix is increased 1,000-fold (Goulson et al. 2015 p. 6). These mixtures are ubiquitous throughout managed landscapes in the U.S.

The transition to modern, intensive agriculture that began in the 1940s-1960s ushered in a new era of agriculture that emphasizes the use of agrochemicals especially synthetic pesticides. This change coincides with the beginning of the variable cuckoo bumble bee’s decline in the

1940's (Figure 1) as the amount of pesticide applied in the U.S. increased steadily from the 1950s to the 1980s (Fernandez-Cornejo et al. 2014 p. 11). Although there has been an overall drop in the pounds of pesticide applied over the past several decades, the toxicity of the pesticides in use increased to plants and invertebrates including invertebrate pollinators (Schulz et al. 2021 p. 2). The systematic poisoning of wildlife habitat in agricultural areas continues to accelerate into the present day and has contributed to the variable cuckoo bumble bee's decline.

Herbicides

Changes in farming techniques over the past 80 years for the cultivation of large monoculture cropping systems increased reliance on herbicides and contributed to the loss of florally diverse field margins and weedy annual plants (Goulson 2019 p. 3) that the variable cuckoo bumble bee relies upon for energy and nutrients. The application of massive amounts of herbicides became common practice in row-crop agriculture over the decades from the 1950's to 1980's when greater than 90% of corn and soybean fields were treated with herbicide (Fernandez-Cornejo et al. 2014 p. 13). The increased use of herbicide in combination with increased field size destroyed valuable plant diversity along field margins that is absolutely necessary to sustain animal populations that need nectar and pollen throughout the year (Kleijn et al. 2015 p. 4). Analysis of the relationship between the amount of herbicides used across the United States as a proxy for field margin habitat health showed that the amount of herbicide used has a demonstrable negative relationship to populations of the American bumble bee (Szabo et al. 2012 p. 236). This once common species has declined in part because of the increase in herbicide use across agricultural land and brought the populations of the variable cuckoo bumble be down with it.

Any remaining variable cuckoo bumble bee populations that exist since the last known observations in 1999 face considerable new threats from the widespread planting of genetically-engineered, herbicide-resistant corn, soybeans, and other crops in the Corn Belt region of the United States (Malcolm 2018 p. 282). This area historically hosted an abundance of the variable cuckoo bumble bee; but after two decades of increasing herbicide usage (USGS n.d. p. 2) and the nearly ubiquitous adoption of glyphosate-resistant "Roundup Ready" corn and soybeans, there has been a precipitous decline of common milkweed and many other common flowering weeds (Pleasants & Oberhauser 2013 p. 136). Monsanto introduced Roundup Ready soybeans in 1996 and Roundup Ready corn in 1998, and by 2020, genetically-engineered herbicide-resistant varieties comprised 94 percent of soybeans,79 percent of corn, and 83 percent cotton grown in the United States (USDA 2020 entire). Between 1995, and 2013 total glyphosate use on corn and soybeans rose from 10 million to 204 million pounds per year—a 20-fold increase (USGS 2017a p. 3).

Newer herbicide-resistant crops that are genetically engineered to be resistant to multiple herbicides including such as 2,4-D, dicamba, or glufosinate continue the chemical onslaught of agricultural land. Dicamba is notoriously drift-prone moving far beyond the boundaries of crop

fields to affect wild plants growing nearby. The scale of off-target movement of dicamba has the potential to degrade habitat on a level that has not been seen since glyphosate use began to explode nearly 30 years ago. Dicamba levels far below those estimated to be contained in particle and vapor drift are known to reduce plant diversity (Egan et al. 2014 p. 80). Similarly, drift-level rates of dicamba were found to reduce flowering of multiple plants, a reduction scientists have found coincides with reduced visitation by pollinators (Bohnenblust et al. 2016 p. 147). Plants that exist in the margins between agricultural fields are some of the only sources of biodiversity in the sea of crop monocultures that extend across much of the Midwest. The variable cuckoo bumble bee will struggle to recover in an environment sterilized of plants that are vital to its survival.

Fungicides

Many commonly used fungicides in agriculture cause serious sublethal harm to the variable cuckoo bumble bee. Fungicides are ubiquitous in agricultural settings and have been found in the great majority (88%) of bumble bees in a farmland survey (Botias et al. 2017 p. 7). Colonies exposed to fungicides like chlorothalonil produce smaller reproductive females (Bernauer et al. 2015 p. 481) which lowers the ability of the next generation of cuckoo bumble bee females to successfully take over a host nest. Fungicides also interfere with a bee's microbiome and cellular processes which impact their overall health and immune system and increase the disease risk from the microsporidian *Nosema spp*. (Pettis et al. 2013 p. 4). Chlorothalonil usage was the strongest predictor of *Nosema* infection among declining bumble bees in the United States, including the American bumble bee (McArt et al. 2017 p. 6). Chlorothalonil and triazole fungicides inhibit compounds and enzymes in honey bees that detoxify compounds within the cell and downregulate genes involved in producing energy in the mitochondria (Mao et al. 2017 p. 5). These fungicides reduce a bee's ability to extract energy from pollen and nectar and reduce the ability to detoxify its body resulting in a build-up of toxic compounds that weaken the bee (Mao et al. 2017 p. 5) making them more susceptible to infection.

While fungicides are not acutely toxic to bumble bees, mixtures of fungicides and certain pyrethroids and neonicotinoids are known to have acute synergistic effects (Pilling & Jepson 1993 p. 296; Raimets et al. 2018 p. 543) by greatly increasing the toxicity of the insecticide. Colonies exposed to fungicides like chlorothalonil produce smaller reproductive females (Bernauer et al. 2015 p. 481) which impacts the survival of the next generation for the variable cuckoo bumble bee. Even when fungicides are sprayed prior to bloom, the nectar and pollen of flowering crops like almonds have reduced fungal richness which can have consequences for the natural fermentation of pollen provisions—"bee bread"—including increasing fungal infections like chalk brood in honey bees (Yoder et al. 2013 p. 596).

Insecticides

Insecticides threaten the variable cuckoo bumble bee because they are acutely toxic and persist in the environment resulting in chronic, low dose exposure. A toxic legacy of numerous insecticidal compounds likely contributed to the decline of the variable cuckoo bumble bee over eight decades of decline. Organochlorines, carbamates, pyrethroids, organophosphates, and other insecticide groups became commonly used on farmland over this time-period which directly and indirectly poisoned insects (Goulson et al. 2015 p. 1) including the variable cuckoo bumble bee. While the total number of pounds of insecticide has declined over the past several decades (Fernandez-Cornejo et al. 2014 p. 11), the toxicity of the insecticides to invertebrates including pollinators has consistently increased (Schulz et al. 2021 p. 2). Therefore, the total toxic load on the environment and on the variable cuckoo bumble bee has continued to increase over its multiple decade decline.

Populations of the variable cuckoo bumble bee that may still be present now face the toxic effects of the newest and now most commonly used class of insecticides in America, the neonicotinoids (Simon-Delso et al. 2015 pp. 8–11) which are a group of synthetically produced, systematic pesticides that are strongly implicated in bumble bee declines (Goulson et al. 2015 p. 5). Neonicotinoids present a toxic problem to the future of the variable cuckoo bumble bee because they impair the survival of the American bumble bee. Since 2009, more than 90% of neonicotinoid literature has shown direct or indirect harms to bees associated with sub-lethal exposure to neonicotinoids (Lu et al. 2020 p. 12). Neonicotinoids are used on at least 140 different crops (Simon-Delso et al. 2015 p. 8) on over half of the cropland in the United States (DiBartolomeis et al. 2019 p. 7) and are likely to continue to be used extensively in the near future. The states that have seen some of the largest declines in the American bumble bee within the past 20 years are the same states that have seen the largest increases in quantified neonicotinoids use (Tyler & Bombus Pollinators Association of Law Students 2021 pp. 43–46).

Neonicotinoid insecticides adversely affect all members of a bumble bee colony, especially reproductive members. At sub-lethal levels, neonicotinoids impair reproduction: for example, thiamethoxam impairs ovary development in bumble bees (Baron et al. 2017 p. 4) and impairs sperm viability in bumble bees (Minnameyer et al. 2021 pp. 20–21). Imidacloprid causes reductions in both reproductive success and production of reproductive females (Whitehorn et al. 2012 pp. 1–2; Wu-Smart & Spivak 2018 pp. 4–5; Raine 2018 p. 1). In addition to reproductive consequences, neonicotinoids impair normal functioning of colonies making them less able to learn and remember (Siviter et al. 2018 p. 5), disrupt circadian rhythm and sleep (Kiah et al. 2021 pp. 7–9), can reduce their foraging motivation (Lämsä et al. 2018 p. 4), and reduce foraging efficiency (Feltham et al. 2014 p. 9). Impacts to workers reduces the foraging potential of the colony and therefore the cuckoo female cannot produce as many new reproductive females which can result in significant reductions in their populations.

The variable cuckoo bumble bee's host, the American bumble bee inhabits open farmland and fields (Williams et al. 2014 p. 149) across its entire range where toxic neonicotinoids are used on a variety of crops. The largest potential non-seed coating use of neonicotinoids are on the top crops in the country: corn, soy, cotton, and wheat (Dibartolomeis et al. 2019 p. 7). The largest corn and soy producing states are in the Midwest (USDA 2020b Table 1-36) where the variable cuckoo and American bumble bees was once abundant, but now have seriously declined (Richardson 2021). Several states are known for their production of specialty orchard, vineyard, and vegetable crops which rely on the most popular neonicotinoid—imidacloprid—to control their pests (USGS 2017 p. 3). The production of apple crops in New York (US Department of Agriculture 2019a p. 1) and Michigan (US Department of Agriculture 2019b p. 1), pecans in Georgia (US Department of Agriculture 2019c p. 1), and citrus in Florida (U.S. Deparment of Agriculture 2020c p. 1) all involve large amounts of insecticides being released into the environment, contaminating the nectar and pollen from the fruit trees and surrounding pollen and nectar sources. The states that have seen some of the largest declines in the American bumble bee within the past 20 years are the same states that have seen the largest increases in quantified neonicotinoids use (Tyler & Bombus Pollinators Association of Law Students 2021 pp. 43–46).

6.3. Other Natural or Manmade Threats

6.3.1. Pathogen Spillover

Pathogen spillover from domesticated bees is a major contributing factor to the declines of bumble bees (Cameron & Sadd 2020 pp. 9–11). Pathogen spillover occurs when pathogens (viruses, bacteria, parasites, etc.) are passed from one heavily infected 'reservoir' population to a suitable species or population that has low levels of infection (Colla et al. 2006 p. 461). Many pathogens infect bumble bees and these pathogens transmit from colony to colony primarily through shared flowers (Figueroa et al. 2019 p. 1). When bumble bees forage on flowers, they leave behind pathogen particles especially through their propensity to defecate on the flowers they visit (Figueroa et al. 2019 pp. 5–7).

Pathogen spillover from domesticated honey and bumble bees has been heavily implicated as a contributing factor to the decline of North American bumble bees (Cameron & Sadd 2020 p. 3). The American bumble bee's decline started around the year 2000 (Figure 2) which coincides with rapid increases in the use of domesticated bumble bees (primarily Bombus impatiens) to pollinate crops in greenhouses and for outdoor crops (Velthius and Vandoorn 2006 p. 429) as well as an explosion in the use of neonicotinoid insecticides which weaken bumble bee's ability to fight infection (see threat section A.2). Domesticated bumble bees have only been widely used for crop pollination since the late 1990s and early 2000s (Velthius and Vandoorn 2006 p. 429), but their use is expected to continue to increase (see e.g. Velthius and Vandoorn 2006 p. 433) because the demand for greenhouse pollination service is increasing, with the greenhouse area under production for tomatoes increasing by almost 50% from 2007-2017 and the area under production for other vegetables increasing 75% from 2002-2017 (USDA AgStats

2020). Commercially raised bumble bees often have high levels of infection and have been shown to spread parasites to wild bumble bees outside greenhouses (Colla et al. 2006 pp. 463-465; Graystock et al. 2013 p. 1210). Szabo et al. (2012, p.235) demonstrated that the rising use of domesticated bumble bees correlated with the decline of the American bumble bee and showed a tight connection, even more demonstrable than other causes of decline such as pesticide use and habitat destruction. The Northeast and the upper Midwest have seen the greatest increase in the number of farms using greenhouses that require bumble bees for pollination and these areas have also seen the greatest declines of the American bumble bee (Figure 4).

Nosema bombi and *N. ceranae*

The microsporidians *Nosema bombi* and *N. ceranae* contribute significantly to the decline of the variable cuckoo bumble bee's host by spreading from domesticated colonies (Szabo et al. 2012 p. 235). *Nosema spp*. are parasites related to fungi that spread through the release of highly resistant, long-lived spores in feces (Otti & Schmid-Hempel 2007 p. 119). *Nosema spp.* replicate within the midgut of the bee by infecting and damaging cells and then is excreted in the hive or onto flowers (Otti & Schmid-Hempel 2007 p. 119). Both *N. bombi* and *N. carinae* infect bumble bees and spillover from honey bees and domesticated bumble bees, negatively impacting wild colony growth, immune function, and reproduction (Graystock et al. 2013b p. 1212, 2016 p. 68; Fürst et al. 2014 pp. 3–4). *N. bombi* is known to have infected North American bumble bees prior to the introduction of domesticated colonies and causes lowers colony-level fitness in lab and field experiments by reducing the number of reproductive members and the number of workers (Otti & Schmid-Hempel 2008 p. 579). *N. ceranae* is a parasite of the Asian honey bee (*Apis ceranae*) that infects the European honey bee (*Apis mellifera*) and is known to spillover from honey bees to wild bumble bees (Graystock et al. 2016 p. 68) reducing bumblebee survival with additional sub-lethal effects on behavior (Graystock et al. 2013a pp. 116–117).

Contaminated feces from commercially reared bumble bees and infected wild bees are spread onto flowers that are visited by non-infected wild bumble bee populations (Colla et al. 2006 p. 465; Szabo et al. 2012 p. 232). It is likely that *N. bombi* spilled over into domesticated colonies which then facilitated the spread of *N. bombi* to other wild bumble bees because of their transportation and propagation (Graystock et al. 2016 p. 69). The spillover of both parasites is made worse because of the movement of domesticated bumble bee colonies around the country and their potential to contaminate flowers that are shared with wild bumble bees.

The variable cuckoo bumble bee's host is particularly vulnerable to the spread of pathogens because they have lower genetic diversity relative to other bumble bees, which limits the natural variation in the species that would provide immunity to diseases (Lozier et al. 2011 pp. 4883–4884). Surveys of north American bumble bees showed that 15.2% of American bumble bees sampled were infected with the microparasite *Nosema bombi* which is a higher rate compared to North American bumble bee species with stable populations (Cameron et al. 2011 p.

664). American bumble bee specimens from museums had very low rates of infection of *N. bombi* before 1980 and significantly higher rates of infection in specimens from after the late 1990s (Cameron et al. 2016 p. 4387). The combination of lower genetic diversity and increasing spread of parasites presents a major threat to the American bumble bee which is not adequately addressed by current laws governing the inter-state movement of domesticated bumble bees (see threat section E.2).

6.3.2. Climate Change

Global climate change poses a major indirect threat to the variable cuckoo bumble bee (Cameron & Sadd 2020 pp. 8–9). Global climate change's impact on temperature and precipitation is threatening stability of the plant resources that the variable cuckoo bumble bee relies on for food and habitat (Cameron & Sadd 2020 p. 9). Due to climate change-related temporal shifts in flowering or phenological patterns of these plants, the variable cuckoo bumble bee and its host's phenology may become mismatched with certain plants and lead to gaps in the availability of food resources (Schweiger et al. 2010 p. 779). Climate change can also reduce the quality of nectar resources for bumble bees which can reduce longevity (Hoover et al. 2012 p. 14).

Human activities have increased global average temperatures 0.8-1.2°C above pre-industrial levels with a trend of about 0.2°C per decade due to past and current emissions (Intergovernmental Panel on Climate Change 2018 p. 4). At current emissions rates, global temperatures will increase by 1.5°C between 2030-2052, resulting in sea level rise, increased incidence of severe weather events, and loss of ecosystems (Intergovernmental Panel on Climate Change 2018 p. 4). Average temperatures have already risen across the large range of the variable cuckoo bumble bee with increases in the southern great plains, the midwestern, northeastern, and southwestern parts of the country; of 0.76 F, 1.26F, 1.43F, and 1.61F, respectively (Vose et al. 2017 Table 6.1).

Bumble bees have evolved to fly and forage at lower temperatures than other bees and are found at higher latitudes and altitudes (Heinrich 1972 p. 185). However, above 24°C, bumble bees lose the ability to maintain a stable body temperature (Heinrich 1972 p. 186) and they are unable to fly if their thorax temperature exceeds 42-44°C (Goulson 2010 p. 17). A reduction in the length of time bumble bees can fly results in fewer foraging trips and thus fewer resources to rear large colonies; indeed, bumble bees have been extirpated from areas with extreme temperatures, independent of land use in some cases (Kerr et al. 2015 p. 179; Soroye et al. 2020 p. 687).

Disruptive range shifts are also possible as a result of climate change at the northern and southern extents of the variable cuckoo bumble bee's host species (Cameron & Sadd 2020 p. 8). For example, the southern portion of North American bumble bee's ranges are shrinking due to rising temperatures (Kerr et al. 2015 p. 178). However, a proportional shift northward to remain

within the preferred temperature range is not occurring and is leading to a "range compression" of North American's bumble bees (Kerr et al. 2015 p. 178; Soroye et al. 2020 p. 687). The variable cuckoo bumble bee's host is a good example of a species experiencing range compression based on populations losses throughout the entire northern part of its range (Figure 4). The American bumble bee is not moving northward to keep up with climate change which means it is more vulnerable to increasing temperature with subsequent adverse effects to the variable cuckoo bumble bee.

6.3.3. Loss of Genetic Diversity and Production of Diploid Males

With no recent observations, any remaining populations of the variable cuckoo bumble bee are likely to be isolated from one another and at risk of inbreeding depression resulting from small population size (Darvill et al. 2006 p. 602). Bumble bees likely disperse up to 10 km (6.2 miles), but typical dispersal is most likely three km (1.86 miles) (USFWS 2018 p. 21). Bumble bee colonies exist in metapopulations dependent on connected populations and habitat patches to avoid inbreeding depression and restore population viability via dispersal (Hanski & Gyllenberg 1993 pp. 36–38). Bumble bee populations that are in decline exhibit a loss of genetic diversity and gene flow over time, while stable populations are less likely to show such changes (Lozier et al. 2011 p. 4883). The risk of inbreeding depression highlights the need for connectivity between colonies and habitat patches, and thus the need for protection of designated critical habitat that provides for sufficient floral resources and nesting sites as well as dispersal to mitigate the threats of small populations.

Declining genetic diversity can have the effect of accelerating population decline via the "diploid male extinction vortex" (Grozinger & Zayed 2020 p. 278). Bumble bees are uniquely vulnerable to the loss of genetic diversity because their sex is determined by a genotype at a single loci (Zayed 2009 p. 239). This genetic phenomenon is called haplodiploidy and a single loci sex determination in which haploid males (single set of chromosomes) develop from unfertilized eggs while diploid (two sets of chromosomes) females develop from fertilized eggs (Zayed & Packer 2009 p. 239). This sex determination system in small populations with limited gene flow makes the variable cuckoo bumble bee particularly susceptible to inbreeding depression and is a major threat to population viability (Zayed 2009 p. 244). Small and inbred populations can produce sterile diploid males when females fertilize eggs with sperm that has the same allele at the sex-determination locus (Zayed 2009 p. 239). In addition, females fertilize eggs to produce females and thus waste reproductive effort when males are inadvertently produced, leading to increased male biased sex ratio and further reduced population sizes, creating a positive feedback loop that ultimately leads to extinction (Zayed & Packer 2005 pp. 10744–10745; Zayed 2009 pp. 239, 241). The production of diploid males in haplodiploid bees can increase extinction risk by 50-63%, an order of magnitude higher than extinction risk caused by inbreeding alone, making diploid male production a unique and serious threat to the variable cuckoo bumble bee (Zayed & Packer 2005 pp. 10744–10745).

6.3.4. Combined Threats

The combination of threats from loss of host species, disease, pesticides, and habitat loss, enhance the extinction risk from any single threat for the variable cuckoo bumble bee (Brown et al. 2000 p. 425; Fauser-Misslin et al. 2014 pp. 453–455; Goulson et al. 2015 p. 6). It is highly unlikely that any one threat has acted to precipitate the decline of the variable cuckoo bumble bee, rather a combination of factors creates conditions that amplify impacts. For the variable cuckoo bumble bee, the loss of the host species was likely made worse because of threats to habitat. Interestingly, because the host species remained relatively abundant overall until the 1990s (Figure 2) this indicates that the variable cuckoo bumble bee's decline from the 1940's-1990's was driven by more than just steep decline of the host species. Multiple threats including habitat loss, pesticides, disease, honey bee competition, or changes in the host population stability may have contributed.

The American bumble bee faces numerous threats from habitat loss which reduces the available floral resources needed to support healthy colonies (Hatfield et al. 2015 p. 5), and a monotonous diet is known to weaken a bumble bee's immune system which can make it more susceptible to disease (Brown et al. 2000 p. 425; Castelli et al. 2020 p. 5). Lack of nutrition also compromises bumble bees' ability to fight off infections and, in turn, infected bumble bees require increased nutrition which takes resources away from colony growth and reproduction (USFWS 2018 p. 66). It is also likely that the American bumble bee's preferred climate and habitat, may interact with nectar and pollen availability to make the populations at the edge of their distribution more vulnerable to declines (Williams 2005 p. 40).

Environmental toxins such as pesticides provide additional acute and chronic stress to bumble bees. Pesticide and pathogen exposure act together to decrease colony growth and reproduction (Botías et al. 2021 pp. 425–426). On top of many other impacts, neonicotinoids are well known to impair a bee's ability to fight pathogen infections. For the host of variable cuckoo bumble bee, the fungicide chlorothalonil is also the strongest predictor of *N. bombi* occurrence and total fungicide use was the best predictor of range loss of the American bumble bee (McArt et al. 2017 p. 6).

Thus, the threats of habitat loss, pathogens, and pesticides together require that the variable cuckoo bumble bee's host species have access to more, quality habitat to combat these threats and recover. The combination of a declining host species, enhanced pathogen spread, habitat degradation, and the rarity of this parasitic species created an extinction vortex where the variable cuckoo bumble bee declined rapidly. Addressing these multiple threats to the variable cuckoo bumble bee and its host requires the power of protection under the Endangered Species Act and the concurrent designation of critical habitat.

6.4. Inadequacy of Existing Regulatory Mechanisms

Existing federal, state, and local regulatory mechanisms are inadequate to protect against the threats to the variable cuckoo bumble bee, which include habitat destruction and modification, disease, climate change and the use of pesticides. There are no current regulations that offer explicit legal protected status for the variable cuckoo bumble bee at the federal or state level. Current regulations and designations that incidentally protect the variable cuckoo bumble bee are the result of planning and informational documents such as state wildlife action plans (SWAPs) that are not legally binding and present voluntary recommendations.

Any voluntary measures taken to protect the variable cuckoo bumble bee or promote pollinator habitat generally throughout the species' range are inadequate to address the threats across the range of the variable cuckoo bumble bee and its host species. To the extent that any voluntary, i.e., non-regulatory, mechanisms exist to protect the variable cuckoo bumble bee, FWS cannot rely on voluntary measures to deny listing of species. Voluntary and unenforceable conservation efforts are simply *per se* insufficient as "regulatory mechanisms" under 16 U.S.C. 1533(a)(1)(d):

> [T]he Secretary may not rely on plans for future actions to reduce threats and protect a species as a basis for deciding that listing is not currently warranted . . . . For the same reason that the Secretary may not rely on future actions, he should not be able to rely on unenforceable efforts. Absent some method of enforcing compliance, protection of a species can never be assured. Voluntary actions, like those planned in the future, are necessarily speculative . . . . Therefore, voluntary or future conservation efforts by a state should be given no weight in the listing decision (*Oregon Natural Resources Council v. Daley,* 6 F. Supp.2d 1139, 1154-155 (D. Or. 1998).

This species is recognized as imperiled or needing protection by international and state entities, but recognition is not a form of legal protection. Internationally, NatureServe ranks the variable cuckoo bumble bee as G1 or critically imperiled from 2018 (NatureServe 2018 p. 1) and is considered critically endangered by the International Union for the Conservation of Nature (IUCN) (Hatfield et al. 2016 p. 2). NatureServe and the IUCN designations are non-regulatory and are for informational purposes only. Outside the United States the variable cuckoo bumble bee is on the species specialist subcommittee candidate list (Group 2) according to the Committee on the Status of Wildlife in Canada (COSEWIC) (COSEWIC 2021 p. 3). At the state level, the variable cuckoo bumble bee is not formally protected under any state endangered species acts. The variable cuckoo bumble bee is a "species of great conservation need" (SGCN) in Florida (Florida Fish and Wildlife Conservation Commission 2019 p. 62), Maryland (Maryland Department of Natural Resources 2015 p. 76), Nebraska (Schneider et al. 2018 p. 89), Oklahoma (Oklahoma Department of Wildlife Conservation 2016 p. 407), Virginia (Virginia

Department of Game and Inland Fisheries 2015 p. 1134), and is on the invertebrate watch list in Illinois (Illinois Department of Natural Resources 2015 p. 274) (Table 2).

The Center submitted a Freedom of Information Act (FOIA) request to the US Fish and Wildlife Service (FWS) regarding any reports, consultations, and emails that reference the variable cuckoo bumble bee and received a response on Dec. 22nd, 2020. The Center considers these FOIA records to be representative of the information possessed by FWS. We received from Regions 2-6, a response of 585 pages and six excel files. These files broadly contained references to the variable cuckoo bumble bee in several reports, emails, some state level actions, and limited observational information. This FOIA response revealed that no specific research or monitoring has been done for the variable cuckoo bumble bee, yet FWS knows that this species is at risk. As of 2020, the variable cuckoo bumble bee is a priority species under FWS's at risk species prioritization project. This species is also priority/covered species lists at the Virginia Division of Natural Heritage and under the New England Pollinator Partnership. Additionally, from FOIA responses related to the petition for the American bumble bee, FWS has access to Dr. Richardson's bumble bee database and can verify any claims related to observations of this species. Overall, these FOIA records confirm that FWS is aware of the status of this species, but there are no existing regulatory mechanisms adequate to protect the variable cuckoo bumble bee from its myriad threats. All documents obtained in this FOIA request will be included in the supplemental files for this petition. Listing the variable cuckoo bumble bee and its host under the Endangered Species Act is the only adequate regulatory mechanism available to protect the variable cuckoo bumble bee.

6.4.1. Federal Mechanisms

Several federal regulations have the stated purpose of properly managing and protecting habitat for wildlife, but there are currently none that directly address the variable cuckoo bumble bee, the American bumble bee, or a similar species across the entire or even a large portion of the range of the variable cuckoo bumble bee.

The most comprehensive database of bumble bee observations available indicates that the variable cuckoo bumble bee and its host survive almost entirely on privately held lands that offer no regulatory conservation mechanisms for this bee. There are 79 historic observations for the variable cuckoo bumble bee that are on currently held public land representing 6.7% of all historic observations (Clauser 2021). Three of the most recent observations from 1995 in Oktibbeha county, Mississippi, on the Sam D. Hamilton Noxubee National Wildlife Refuge (Clauser 2021). Only about 4% of all recent observations (395 out of 9038 observations) of the American bumble bee have been on public land (Clauser 2020). Neither the variable cuckoo bumble bee nor its host rely on the protections offered by public lands. The broad range of the American bumble bee requires broad protections that are provided by the ESA that extend inside and outside federally owned land.

National Forest Management Act

The National Forest Management Act (NFMA) of 1976 regulates the multiple uses of the nation's forests including to "provide for diversity of plant and animal communities…" (g)(3)(B). Additional requirements for forest management based on NFMA state that to comply with ecosystem integrity and diversity requirements the plan must "…maintain the diversity of plant and animal communities and support the persistence of most native species in the plan area." (219.9) This regulation is inadequate for the conservation of the variable cuckoo bumble bee because it does not require the responsible agency to support the persistence of **all** species and thus opens a gap that allows the Service to ignore certain species that may not be considered "focal species", keystone species, or charismatic in some way. None-the-less the variable cuckoo bumble bee is considered by six states a "species of conservation concern", and as outlined in NFMA planning regulation (219.9), there are no requirements under NFMA to investigate or address the known decline of a native species that is not already protected under the ESA. Elevating the variable cuckoo bumble bee to the status of a proposed and then a protected species is the best way to engage state and federal agencies to collectively address a species decline across the western United States.

Federal Land Policy and Management Act

The Federal Land Policy and Management Act (FLPMA) of 1976 regulates the "management, protection, development, and enhancement of public lands" with the intention to "…preserve and protect certain public lands in their natural condition; that will provide food and habitat for fish and wildlife…" (FLPMA). Under this act, grazing is regulated by the creation of management plans, but there are no explicit provisions that require range allotments to maintain existing levels of biodiversity in any capacity. This regulation does not provide robust protections from the threat of overgrazing or from the spread disease for the variable cuckoo bumble bee.

National Environmental Policy Act

The National Environmental Policy Act (NEPA) is America's foundational environmental law for protecting the environment. NEPA is a national charter for establishing policy, setting goals, and carrying out policies that relate to the environment. This act requires Federal agencies to consider the effects of their actions on the environment through the utilization of environmental assessments and environmental impact statements. These reports must disclose any adverse impacts to the environment including to sensitive species such as the variable cuckoo bumble bee. However, the law only requires agencies to disclose the impacts of their actions; it does not prohibit agencies from choosing alternatives that will negatively affect individuals or populations of the variable cuckoo bumble bee.

Without protection of the Endangered Species Act and concurrent designation of critical habitat, the USFS and BLM will not be triggered to consult with the Service on placement of apiaries on their lands within the variable cuckoo bumble bee's range. Thus, the impacts of apiary placement on USFS lands to the health and survival of the variable cuckoo bumble bee

and its host will not be assessed and continue to be a threat to the bee. Placing honey bee hives on public, protected land is inconsistent with protecting sensitive species like the variable cuckoo bumble bee (Geldmann & González-Varo 2018 pp. 1–2).

The Wilderness Act

The Wilderness Act of 1964 (*Wildnerness Act* 1964 p. 1) established the National Wilderness Preservation System and identified four federal agencies responsible for protecting wilderness areas. The Wilderness Act allows for the designation of protected wilderness areas on public land to "…retain its primeval character and influence, without permanent improvements or human habitation…" (*Wildnerness Act* 1964 p. 1). Wilderness areas protect many species from human impacts; however, the variable cuckoo bumble bee is not currently found in any designated wilderness areas; therefore, the protection, offered by these lands, is irrelevant.

Other Federal regulatory mechanisms

The Forest Service, Bureau of Land Management, and other Federal agencies are subject to several other acts and regulations that affect forests of the United States. The Healthy Forest Reserve Program (HFRP) provides incentives for restoration of privately-owned forests, however, the variable cuckoo bumble bee is not known to inhabit any privately held forested lands, so this restoration initiative does not apply. The variable cuckoo bumble bee has been observed near some privately held, primarily agricultural land, but it not known if any of the populations are near sufficient Cropland Reserve Program (CRP) land to benefit from their conservation. The variable cuckoo bumble bee is only known to have occurred on the Sam D. Hamilton Noxubee National Wildlife Refuge. This protection only benefits a miniscule part of the historic range of the bee.

Related Species Protections under the Endangered Species Act

There are no other species protected under the Endangered Species Act that would coincidentally provide sufficient protection for the variable cuckoo bumble bee and its host. The ESA offers protection for only one other bee in the continental United States—the rusty patch bumble bee. The range of the rusty patch extends from Minnesota to Indiana and south into Iowa and Illinois. The rusty-patched bumble bee is another wide ranging, generalist bumble bee, but its protected status provides inadequate protection across the vast range of the variable cuckoo bumble bee and its host the American bumble bee. The rusty-patched bumble bee's historic range does overlap with areas where the American bumble bee is declining in the upper Midwest and northeastern United States. However, the rusty-patched bumble bee has been denied designated critical habitat and has declined to relatively very few populations that are spread sporadically across 41 counties which represents only 11% of historically occupied counties (Szymanski et al. 2016 p. 35). Therefore, the rusty-patched bumble bee's currently limited, sporadic distribution does not provide significant overlap with the larger range of the American bumble bee. FWS has described areas of high and low habitat potential for the rusty-patched bumble bee (USFWS n.d. p. 1) and only 246 (188 low potential and 58 high potential) of the 9,038 recent observations of the American bumble bee are located within rusty-patched bumble

bee potential habitat (Clauser 2020). The protections for the rusty-patched bumble bee offer limited habitat protections without critical habitat designation, but they also fail to address other threats. EPA has not consulted with the FWS on pesticide registrations that would harm this bee, and in terms of addressing disease, the current draft recovery plan for the rusty-patched bumble bee states that "…disease epidemic prevention plans…may be used…" but does not describe in any detail the nature of these plans or how they would be implemented (USFWS 2019 p. 7). The ESA protections for the rusty-patched bumble bee are therefore nowhere near sufficient to protect the variable cuckoo bumble bee and its host within the historic range of the rusty-patched bumble bee.

Other grassland insect species are protected under the ESA within the range of the variable cuckoo bumble bee, but they protect only a fraction of the bee's range. Wide-ranging, grassland species of butterflies within the range of the variable cuckoo include: the Dakota skipper (*Hesperia dakotae*), the Poweshiek skipperling (*Oarisma poweshiek*), and the Karner blue (*Lycaeides melissa samuelis*). The Dakota skipper and Poweshiek skipperling exist only in native prairie remnants which cover very small areas throughout their former range (USFWS 2014 p. 63717), so the protections offered by these species protects very little habitat overall for the variable cuckoo bumble bee and its host which is able to survive in agricultural and urban areas in the upper Midwest. The Karner Blue butterfly has a large historic range across the upper Midwest and into the northeastern states, however the remnant oak savannah and pine barren habitat with its host lupine is highly fragmented and degraded (USFWS 2003 p. 1) and represents a very narrow portion of the possible habitat that would be suitable for the American bumble bee. These butterfly listings together would not provide protection across the wide range of the variable cuckoo bumble bee and its host.

Pesticide Regulations

The US Environmental Protection Agency (EPA) evaluates the risk of pesticides to bees by using honey bees as a surrogate for all native bees. Bumble bee physiology, behavior, and life cycle characteristics differ from honey bees in myriad ways that are not considered when tests are applied only to honey bees. For example, bumble bee larvae are fed raw pollen and nectar whereas honey bees process nectar and pollen within nurse bees digestive systems before feeding larvae (Fischer & Moriarty 2014 p. 53). Bumble bee larvae are also in direct contact with raw nectar and pollen provisions rather than in individual cells like honey bees and therefore have a different exposure profile (Fischer & Moriarty 2014 p. 53). Further, the persistent residues of pesticides in soil can contaminate bumble bee nests and overwintering sites but this not considered by the EPA when assessing risk to a species that spends its entire life above ground.

Pesticide risk assessments are conducted on only single active ingredients yet pesticides can have additive or synergistic effects whereby two or more active ingredients may have a more toxic effect than either chemical on its own (Andersch et al. 2010 p. 1). Further, inert ingredients are not tested. It is common practice for pesticide applicators to mix multiple pesticides together,

and multiple chemicals are brought back to the nests of non-honey bees (Hladik et al. 2016 p. 473). There is no current EPA testing protocol to determine the synergistic risk from pesticides or their inert ingredients despite evidence for these effects.

Additionally, EPA's response to bumble bee kills have been inadequate in the face of persistent and systemic neonicotinoid pesticides. In 2013, the legal application of neonicotinoid insecticides to *Tilia* trees in Oregon killed massive numbers of bumble bees that contacted poisoned flowers (Hilburn 2013 p. 1). In response, the EPA now prevents foliar applications of nitroguanidine neonicotinoids on non-agricultural plants while plants are flowering (Bradbury 2013 pp. 2–5). However, these systemic neonicotinoids can remain in plant tissue for weeks to years after application (Mach et al. 2018 p. 867), therefore this change in regulation was inadequate to protect bumble bees that will continue to feed on the poisoned nectar of these trees. The state of Oregon banned the use of nitroguanidine neonicotinoids on *Tilia* trees, however this regulation does not protect any part of the variable cuckoo bumble bee's range. We are not aware of any other state restrictions of this type within the range of the variable cuckoo bumble bee.

Honey Bee and Bumble Bee Regulations

No government at any level has taken meaningful action to address this treat, despite the fact that it was known early on that the transport of domesticated bees can quickly introduce new diseases and parasites that could negatively affect wild bumble bee populations (Daszak et al. 2000 p. 446). Federal regulations regarding honey bees are insufficient to protect bumble bees from transmitted diseases. Honey bees are regulated by the United States Department of Agriculture (USDA) and the Animal and Plant Health Inspection Service (APHIS) as agricultural commodities. USDA has the power to slow the spread of honey bee diseases to native species through the Honey Bee Act of 1922 which is intended to restrict the importation and movement of honey bees into and around the country ("7 U.S. Code § 281 - Honeybee importation" n.d.). Apiculturists move their honey bees great distances around the country and weak laws at the federal and state level lead to the transmission and spread of diseases to wild bumble bees. There is abundance evidence that diseases spread by honey bees and domesticated bumble bees have already contributed to the declines of several species including the western bumble bee and American bumble bee (described above). However, this Act has not prevented honey bees from entering National Forests and other public lands (36 CFR § 220.6).

In response to this threat to native bees and plants, the Center and others have recently petitioned the USFS to reexamine the permitting of honey bee hives on public land (Grand Canyon Trust et al. 2020 p. 1-3). Permitting honey bee hives does not represent a minor use for national forest and other public land and should require environmental assessments like other uses.

The Honey Bee Act is specific to honey bees and does not regulate diseases in managed bumble bees; nor is there an equivalent act or law that would regulate bumble bees. The USDA

allows the international movement of managed Canadian bumble bees into the United States which include: the eastern bumble bee (*Bombus impatiens*) and the western bumble bee (*Bombus occidentalis*) (7 CFR § 322.5). The current regulations do not require any imported bumble bees to be inspected or tested for diseases (7 CFR § 322.5). Managed bumble bees can easily escape greenhouses unless they are properly maintained and native bees can acquire pathogens after visiting the same flower as an infected bee (Cameron & Sadd 2020 p. 10.9). This lack of regulation presents a continued threat of disease transmission and direct completion for floral resources to the variable cuckoo bumble bee and other native bumble bees.

6.4.2. State Mechanisms

Across its 28-state range, the variable cuckoo bumble bee is recognized by only six states as needing protection, and no state has legal protection for this species. Indeed, several states do not include insects under their state endangered species act. The variable cuckoo bumble bee is considered by six state wildlife action plans (SWAPs) to be as a species of greatest conservation need (SGCN) in the states of Florida, Illinois, Maryland, Nebraska, Oklahoma, and Virginia (Table 2). Additionally, the host species is also not formally protected under any state ESA, but it is a SGCN in 18 states. SWAPs are non-regulatory documents that provide information on species status and outline the conservation goals of the state. Additionally, the status of "species of greatest conservation need" (SGCN) does not have regulatory status like "threatened" or "endangered" status under any state endangered species act. States are not required by law to carry out what is outlined in them and they are generally not detailed enough to provide specific actions that the state will take for a species. These designations do not constitute adequate regulatory mechanisms and are therefore insufficient to protect the variable cuckoo bumble bee or its host.

Florida

The state of Florida maintains a list of "species of greatest conservation need" as outlined in their SWAP. The variable cuckoo bumble bee is designated as a SGCN in Florida (Florida Fish and Wildlife Conservation Commission 2019 p. 62). Under Florida's Administrative Code 68A-27.005 a species of special concern is protected such that "No person shall take, possess, transport, or sell any species of special concern…" This designation offers some protection for the variable cuckoo bumble bee; however, it hinges on knowledge of the status and population of a species. With no known recent occurrences in Florida since 1995 and no known monitoring programs, this protection is minimal and does not represent an adequate regulatory mechanism to protect this species. Investment in tracking the population of this species is crucial to its survival.

Illinois

The Illinois SWAP has compiled information on species that need conservation which includes species with and without formal protections. The variable cuckoo bumble bee is on the "invertebrate watch list" and has been identified as a species of greatest conservation need (Illinois Department of Natural Resources 2015 p. 274). The SWAP states that the purpose of the watch list "is to prioritize surveys and foster a research agenda to fill knowledge gaps and allow

conservation status assessments to be conducted" (Illinois Department of Natural Resources 2015 p. 10). This designation provides no legal protection and is inadequate for the protection of the variable cuckoo bumble bee.

Maryland

The variable cuckoo bumble bee is listed as a SGCN in Maryland (Maryland Department of Natural Resources 2015 p. 76). The state of Maryland offers legal protected status to species designated as "endangered", "threatened", or "in need of conservation" (Code of Maryland Regulations (COMAR) 8.03.08.), but these designations are not required to be on the SGCN list. The Maryland SWAP considers the variable cuckoo bumble bee as "historic" and possibly extirpated from the state. The variable cuckoo bumble bee has no protected legal status in Maryland and is given the lowest conservation status category.

Nebraska

Nebraska's SWAP designates the variable cuckoo bumble bee as a Tier 2 species at risk (Schneider et al. 2018 p. 89). According the SWAP "Tier 2 species are typically those that are not at-risk from a global or national perspective but are rare or imperiled within Nebraska" (Schneider et al. 2018 p. 1). This tier is the lower of two tiers and reflects lower priority for research and conservation. The SGCN lists in Nebraska "…are used to help prioritize conservation planning and actions and do not have legal or regulatory ramifications" (Schneider et al. 2018 p. 1). This designation is inadequate for the protection of this species.

Oklahoma

The variable cuckoo bumble bee has no legal protection in the state of Oklahoma. This species is designated as a SGCN Tier 2 (Oklahoma Department of Wildlife Conservation 2016 p. 407). The Oklahoma SWAP states that this designation is used "…to identify those species that are in the greatest need of additional conservation attention…" (Oklahoma Department of Wildlife Conservation 2016 p. 384). Identification and information gathering do not constitute legal protections or any guarantee of conservation action by the state.

Virginia

The State of Virginia designated the variable cuckoo bumble bee as a SGCN Tier 1a in the 2015 SWAP (Virginia Department of Game and Inland Fisheries 2015 p. 1134). The state of Virginia has identified the variable cuckoo bumble bees as in critical conservation need because of its low and possibly extirpated population. Ultimately, the purpose of the SGCN designation in SWAPs is to "…identify the distribution and abundance of species of wildlife, including low and declining populations as each State fish and wildlife agency deems appropriate…" (Virginia Department of Game and Inland Fisheries 2015 p. 18). This status provides no legal protection to the variable cuckoo bumble bee.

State Honey Bee Regulation

Regulations on the transportation and inspection of honey bee hives for disease and other threats are inconsistent across states (Mailander 2019 p. 16). For instance, honey bee hive registration is voluntary in Colorado and New York (Mailander 2019 p. 36,40) and even in states with mandatory registration, hobby apiculture is often exempted if a beekeeper has fewer than five hives (Mailander 2019 p. 16). There are no clear regulations that determine how often hives should be screened or for which pathogens as many states provide inspections only at the request of the beekeeper.

7. Request for Critical Habitat Designation

We urge the Service to designate critical habitat for the variable cuckoo bumble bee concurrent with its listing. Critical habitat as defined by Section 3 of the ESA is: (i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the provisions of section 1533 of this title, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) the specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 1533 of this title, upon a determination by the Secretary that such areas are essential for the conservation of the species (16 U.S.C. § 1532(5)).

Congress recognized that the protection of habitat is essential to the recovery and/or survival of listed species, stating that: "classifying a species as endangered or threatened is only the first step in ensuring its survival. Of equal or more importance is the determination of the habitat necessary for that species' continued existence… If the protection of endangered and threatened species depends in large measure on the preservation of the species' habitat, then the ultimate effectiveness of the Endangered Species Act will depend on the designation of critical habitat." H. Rep. No. 94-887 at 3 (1976).

Critical habitat is an effective and important component of the ESA, without which the variable cuckoo bumble bee's chance for survival significantly diminishes. Petitioners request that the Service propose critical habitat for the bee concurrently with its listing.

8. Conclusion

In this petition, we have reviewed the best scientific and commercial information available regarding the historic, present, and future threats facing the variable cuckoo bumble bee and have determined that the species has declined by 100% over a period of eight decades. The variable cuckoo bumble bee is in imminent danger of extinction throughout its range and there is no question that protecting the variable cuckoo bumble bee is warranted under the act as it is imperiled by threats factors 1) the present or threatened destruction, modification, or curtailment of its habitat or range; 3) disease or predation; 4) the inadequacy of existing

regulatory mechanisms; and 5) other natural or manmade factors. Primarily, this species is threatened by the loss of its host species, the American bumble bee which has experienced alarming declines throughout its range and is expected to continue to decline in the near future (Tyler & Bombus Pollinators Association of Law Students 2021 pp. 21–24). The variable cuckoo bumble bee and the American bumble bee face the combined threats of disease transmission from domesticated bees, ongoing habitat loss, and ever-increasing pesticide use which increase the likelihood of continued decline. Additionally, there are no existing regulatory mechanisms which are adequate to protect the variable cuckoo bumble bee. The ESA requires that the Services promptly issue an initial finding as to whether this petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. § 1533(b)(3)(A).

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Personal Communication

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