BEFORE THE SECRETARY OF THE INTERIOR

PETITION TO LIST THE GULF COAST SOLITARY BEE (*Hesperapis oraria*) UNDER THE ENDANGERED SPECIES ACT AND CONCURRENTLY DESIGNATE CRITICAL HABITAT

Female Gulf Coast solitary bee (*Hesperapis oraria*) on Coastal Plain honeycomb head (*Balduina angustifolia*)

Above photo of male by Jim Cane

CENTER FOR BIOLOGICAL DIVERSITY

March 27, 2019

NOTICE OF PETITION

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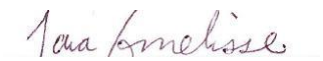
Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. § 1533(b); Section 553(e) of the Administrative Procedure Act, 5 U.S.C. § 553(e); and 50 C.F.R. § 424.14(a), the Center for Biological Diversity hereby petitions the Secretary of the Interior, through the United States Fish and Wildlife Service ("FWS," "Service"), to protect the Gulf Coast solitary bee (*Hesperapis oraria*) 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 Gulf Coast solitary bee concurrently with the species being listed, pursuant to 16 U.S.C. § 1533(a)(3)(A) and 50 C.F.R. § 424.12.

Petitioner is The Center for Biological Diversity ("Center") 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 1.4 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 Gulf Coast solitary bee and its habitat.

Submitted this 27th day of March, 2019



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Executive Summary

Hesperapis oraria, or the Gulf Coast solitary bee, is an extremely rare and declining bee that was described in 1997. The bee has its current known range in secondary or landward dunes on barrier islands and coastal mainland Florida and, historically, in Alabama and Mississippi. The Gulf Coast solitary bee is unique because it is a member of the oldest family and subfamily of bees and is the only known member of its subfamily in the eastern United States. The bee is medium sized and has distinct alternating yellowish and black bands on its abdomen. The females can be distinguished because they have extremely hairy hind legs that assist them in creation of subterranean nests in the sand as well as to carry pollen to those nests. The Gulf Coast solitary bee is also a rare monolege (strict specialist) of the Coastal Plain honeycomb head (*Balduina angustifolia*), a self-incompatible plant. The Gulf Coast solitary bee is not formally protected in any capacity.

The relationship between the Gulf Coast solitary bee and the honeycomb head has evolved over thousands if not millions of years in one of the most unique ecosystems in the world, the northern Gulf Coast. Florida beach state parks alone attract millions of visitors who want to experience this unparalleled ecosystem of soft sand and beautiful floral diversity. The Gulf Coast solitary bee is an integral part of this ecosystem, playing a vital role by effectively pollinating the characteristic honeycomb head, also known as yellow buttons. The bee is both an indicator and flagship species for conservation in the north Gulf Coast dune ecosystems, as its decline indicates the degradation of these fragile areas through loss of biodiversity and its presence serves as an icon for the impact of climate change in these shoreline ecosystems, respectively.

Unfortunately, the Gulf Coast solitary bee is greatly imperiled by urbanization, pesticides, non-native honey bees that compete with the bee and degrade the plant community, sea level rise and severe storms caused by climate change, habitat fragmentation, lack of genetic diversity, and lack of protective regulatory mechanisms. While remaining populations of the bee are in state and national parks, these areas are not managed to protect the bee and activities that threaten the bee are ongoing. The Gulf Coast solitary bee also faces new and looming threats, including increase in sea level rise and incidence of severe storms that destroy its dune habitat as a result of ongoing and future global warming predicted by the latest research. These threats and their synergies have caused the Gulf Coast solitary bee to decline from across its range to only six documented populations. Continuation of threats and lack of protections are causing the demise of this native bee species.

Conservation actions needed to prevent the imminent extinction of the Gulf Coast solitary bee will require managing key threats such as urbanization and pesticide use, mitigating climate change impacts through emissions reductions and inland habitat creation, and controlling non-native honey bees. Critical habitat must provide connected, dense patches of Coastal Plain honeycomb head within open areas of sandy soil that remain undisturbed. The Service must act to protect the Gulf Coast solitary bee to prevent the extinction of the species and its important pollination mutualism that shapes the Gulf Coast dune ecosystem. It is unacceptable to allow this unique representative of specialist ancestral bees and the only member of this native bee genus and subfamily found in this region of the world go extinct. The only hope to save this remarkable native bee from extinction is for the U.S. Fish and Wildlife Service to list it as endangered and designate critical habitat under the under the Endangered Species Act.

Introduction

The health of natural ecosystems and humanity are intricately linked to the health of pollinators (Pollinator Health Task Force 2015 p. 1,8; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2016 p. all). Animal pollination, the vast majority of which is done by bees, is required for successful reproduction of around 90% of wild flowering plants and 75% of leading global food crops, with 35% of the global food supply depending on animal pollinators (Moissett & Buchanan 2011 p. 2; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2016 p. 16). Beyond food production, pollinators play an important role in ensuring the natural production of medicines, biofuels, fibers, construction materials, as well as recreational, cultural, and aesthetic values (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2016 p. 18).

There are over 4,000 species of native, wild, mostly solitary (non-social) bees in the United States that are needed to pollinate the full spectrum of plants in an ecosystem (Aslan et al. 2016 p. 483; Winfree et al. 2018 p. 359). Native bees often provide more effective pollination (i.e. resulting in higher seed set) of native plants than the introduced honey bee (*Apis mellifera*) (Moissett & Buchanan 2011 p. 1; Garibaldi et al. 2013 p. 2). These wild pollinators have declined in diversity, abundance, and occurrence in North America (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2016 pp. 21–22) and are imperiled by a multitude of confounding threats that include habitat loss, agricultural intensification, pesticide use, invasive non-native species, climate change, and pathogens (Pollinator Health Task Force 2015 p. 5; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services 2016 pp. 24–29).

The Gulf Coast Solitary bee (*Hesperapis oraria*) is iconic and unique because it is a floral specialist that feeds only on the emblematic gulf coast plant, the Coastal Plain honeycomb head (*Balduina angustifolia*) and because it is only found within 475 meters from the shoreline of the north Gulf Coast (Hunsberger 2013 p. 41). It is also the only member of its genus and subfamily found in the eastern United States (Cane et al. 1997 p. 242), a status that makes this bee a flagship for conservation of rare and unique native bees in the southern United States.

The Gulf Coast solitary bee is also an indicator of the health of barrier island and gulf coast ecosystems and is threatened by habitat loss, urbanization, pesticide spraying, and climate change. These threats have already reduced its range with confirmed loss of at least four populations, three from the original 15 documented in 1993-1994 and one from a population documented in 2012; today we only know the bee from six sites in Florida (Table 1). Wherever the bee is found, it is in extremely low abundances. Without Endangered Species Act protection and designated critical habitat, the Gulf Coast solitary bee will no doubt become extinct in the near future, a victim of coastal development, pesticides, and anthropogenic climate change.

Natural History

Taxonomy

There is no confusion or dispute over the taxonomic validity of *Hesperapis oraria* Snelling and Stage; it is a member of the order Hymenoptera, family Melittidae, subfamily Dasypodainae tribe Hesperapini (Hedtke et al. 2013 p. 7), genus *Hesperapis*, and subgenus *Carinapis* or the Carinata group

(Cane et al. 1997 p. 238). Melittidae is hypothesized to be the basal group of all bees, with the Dasypodainae the basal most branch in recently constructed phylogenies (Danforth et al. 2006 p. 15120; Hedtke et al. 2013 pp. 3–4). The genus *Hesperapis* is only found in xeric parts of South Africa and North America (Michener 2007 p. 419).

The Gulf Coast solitary bee is the only known member of its genus, *Hesperapis*, and member of subfamily Dasypodainae found in eastern North America, as the other named 39 species are found in xeric grasslands and deserts in western North America (Cane et al. 1997 p. 238 and 242). Most *Hesperapis spp.* are oligolectic, or gather pollen from few plants of related genera in the same family, which, due to the basal position in the bee phylogeny, is considered the ancestral behavior of all bees (Danforth et al. 2006 p. 15122). The genus name *Hesperapis* is derived from the words "evening" and "bee" and the species name *oraria* is Latin meaning of the "coast or shore" (Cane et al. 1997 p. 242).

Description

The Gulf Coast solitary bee was described in 1997 (Cane et al. 1997 p. 238) and appears to be monolectic, only gathering pollen and nectar from one floral host, the Gulf Coastal Plain honeycomb head, *Balduina angustifolia* (Asteraceae) (Cane et al. 1996 p. 238). Females of the Gulf Coast solitary bee are 11-13 mm in length, while males are smaller at 8.5-11 mm long; both sexes have shiny black heads with many hairs, plumose or hairy yellowish mesosomas with clear to brownish wings and hairy dark brown to reddish legs (Cane et al. 1997 pp. 239–240). Hairs on female metathoracic legs differ from males in a way that is thought to assist in nest construction in sand (Lyons et al. 2015 p. 2). Males can further be distinguished from females by their distinctive subtriangular pygidial plate that ends in a point, whereas female pygidial plates are broad with points greater than 45° (Cane et al. 1997 p. 242). Overall, bodies of both sexes are covered in dense hairs and metasomas have alternating dark and light colored bands (Lyons et al. 2015 p. 2).

Life Cycle and Behavior

Adult Gulf Coast solitary bee activity coincides with the bloom of its pollen host, the Coastal Plain honeycomb head, in September and October (Cane et al. 1997 p. 245). In their few weeks as adults, female bees build nests and lay eggs after mating; gulf Coast solitary bees are thought to be univoltine, or produce one generation per year (Lyons et al. 2015 p. 3). Solitary bees are central place foragers, bringing food back to a central nest after long bouts of foraging (Cane 2001 p. 4). Females provision a brood cell with a ball of pollen upon which one egg is laid and left to hatch and develop into likely five instars (Rozen Jr 2016 p. 5). The final larval stage enters diapause as a pre-pupa/post-defecating larvae before pupating and emerge as an adult (Danforth 1999 p. 1986).

Male Gulf Coast solitary bees often sleep on and patrol flowers of the honeycomb head for females and have been observed to attempt matings at the flowers; however as none of those observed mating attempts were successful, it is assumed that the majority of mating occurs at nest sites (Cane et al. 1997 p. 245). Alternatively, patrolling males may have a lower success rate if mating does indeed occur near host plants, such as at the base of the plants (Rozen Jr 1987 p. 6). Males also rest on flowers during severe weather (Cane 1997 p. 73). The activity of males on the flowers contributes to the bee's efficacy as a pollinator of the Coastal Plain honeycomb head.

While the nesting biology of the Gulf Coast solitary bee has not been specifically described, the 14 members of the Carinata group (subgenus of *Hesperapis*) have nests associated with soft sand, such as on dunes (Cane et al. 1997 p. 244). Female Gulf Coast solitary bees have modified hind basitarsi setae that form a trough-like depression used to excavate nests in sandy soils (Cane et al. 1997 p. 244). Other members of the subgenus have been found to nest in aggregate, with upwards of 25 burrows/m^2 in the sandy soil and each burrow housing one to six individual larval cells within a 30 cm radius and around 25-30 cm deep (Rozen Jr 1987 p. 3; Cane et al. 1997 p. 244). Larval cells of *Hesperapis* are not lined by the female and the larvae do not spin cocoons; however, post-defecating larvae have been found to be coated in a rigid integument-like material that may regulate moisture (Rozen Jr 1987 p. 5, 2016 pp. 7–8).

The Gulf Coast solitary bee may exhibit bet hedging, or a reproductive strategy that reduces between year variance in reproductive success and increases overall survival in ecosystems with unpredictable annual weather conditions. In response to unpredictable habitat, bees often enter extended diapause for two or three years, delaying emergence until blooms of their host plants. Monolectic bees do not switch pollen sources if they emerge when their host plant is not in bloom and so have evolved synchrony in emergence time with the blooming period of the plants, using environmental cues for emergence (Danforth 1999 p. 1986 and 1991–92). At least one congener, *Hesperapis rhodocerata*, has been shown to exhibit extended diapause, not emerging until sufficient rainfall resulted in blooms of the preferred pollen host (Rozen Jr 2016 pp. 2–4).

Foraging Range

The flight distance or dispersal radius of a bee species is dependent upon physiological factors as well as external barriers (Zurbuchen et al. 2010b p. 669) and increases with body size (Greenleaf et al. 2007 p. 592). Maximum foraging ranges for bees with lengths measured between 8 and 15 mm ranged from 130 m to 1150 m (Zurbuchen et al. 2010b p. 671). However, in general there is a significant decrease in the number of female bees foraging at increasing distance: for tested bees that had a maximum foraging distances of 1100 m and 1400 m, 75% of females discontinued foraging at 400 m and 700 m, respectively (Zurbuchen et al. 2010b pp. 673–674). Indeed, most individual solitary bees cannot reach foraging maximums and thus require nest and host plant habitat be overlapping to within 100 m (Zurbuchen et al. 2010b p. 675). For example, at 10 mm in length *Andrena humilis* was found to have an average foraging range of only 50 m and habitat patches more than 200 m apart were too isolated to reach based on the movement of marked bees (Franzén & Nilsson 2013 p. 1401).

The Gulf Coast solitary bee's habitat and location is determined by the number of patches of their host plant, the Coastal Plain honeycomb head, requiring at least 12 patches per site, as well as the total area covered by plant patches and distance between those patches (Hunsberger 2013 p. 33). A homing range study of a Melittid ground nesting bee in the genus *Dasypoda* of about the same size or larger than the Gulf Coast solitary bee determined that all bees will find their way back to the nest if released at 250 m, where about half will be successful at 1.7 km (Chmurzyński et al. 1998 p. 424). While the foraging range of the Gulf Coast solitary bee has not been studied, results from the studies discussed above and considering its monolectic foraging and strict nesting requirements, the Gulf Coast solitary bee is estimated to have a maximum foraging distance of around 1000 m, or one km.

Habitat

When described, the Gulf Coast solitary bee was only found on dunes behind fore dunes on barrier islands and coastal shores within 2-3 km from the shoreline (Cane et al. 1997 p. 243), it is now known only within 500 m from the shoreline (Thetford & Miller 2015a p. 5). Barrier islands in the Gulf of Mexico are long and narrow bands of sand that run parallel to the shore from two miles west of Alabama in Mississippi to Destin, Florida in the east (Hunsberger 2013 p. 21). The islands and coastal areas consist of foredunes that break waves coming off of the Gulf and secondary or landward dunes behind foredunes, with grasslands and temporary wetlands in the swales (Hunsberger 2013 p. 21); on wider sections of the islands, such as on Perdido Key, the vegetation in the secondary dunes becomes woody (Hunsberger 2013 p. 22).

As the Gulf Coast solitary bee is monolectic and does not switch host plants, its habitat must consist of both dense patches the Coastal Plain honeycomb head as well as appropriate nesting substrate within flight range of the plants. The Gulf Coast solitary bee uses patches of the honeycomb head less than 475 m from the coastline and, as the plant prefers habitat greater than 110 m from the shore, the bee can most likely be found between 110-475 m from the Gulf coastline (Hunsberger 2013 p. 41). On a regional scale, the bee requires at least 12 patches of the honeycomb head per site and on a landscape scale requires the area of the patches be at least 111.5 m^2, or at least 2.5 plants per m^2 (Hunsberger 2013 pp. 34–35). In 2011-2012, the bee was found in higher densities on the coastal mainland sites which had three times the number of honeycomb head patches compared to the barrier islands (Hunsberger 2013 p. 37).The bee is not found at stands of honeycomb head on non-coastal mainland sites (Hunsberger 2013 pp. 32, 37).

As the Gulf Coast solitary bee's range is much smaller than that of the honeycomb head, its habitat is restricted by several other factors, most likely bare areas of fine sandy soil for nesting (Lyons et al. 2015 p. 3) as well as the intermediate disturbances needed to maintain the bee's dune habitat. Dune habitat is dynamic and disturbance dependent and so constantly changing due to forces of wind, water, storms, and fire, which has led to naturally patchy distribution of the honeycomb head and other vegetation on the dune ecosystem (Hunsberger 2013 p. 20). The bee and plant are found in higher densities on the coastal mainland sites, potentially due to reduced high intensity storm disturbance in these areas (Hunsberger 2013 pp. 40–41). In addition, low intensity fires are a common and natural component of these ecosystems that maintains bare ground and patchy vegetation. The bee's coastal and island habitats are separated from the non-coastal mainland patches of honeycomb head by development or dense vegetation that has built up due to suppression of natural fire, reducing habitat connectivity (Hunsberger 2013 p. 39). As such, the Gulf Coast solitary bee and its host plant appear to require a moderate level of disturbance in their naturally shifting dune habitats.

Nests of the Gulf Coast solitary bees are in the deep, soft sandy soils (Cane et al. 1997 p. 244) and potentially no more than 2 km from the shore, as they are restricted to the crumbly sands in back-dune habitats (Lyons et al. 2015 pp. 2–3); although considering where the adult bees are found, the nests are more likely around 500 m from the gulf shore (Thetford & Miller 2015a p. 5). Nesting resources are key factors in solitary bee population viability; however, Gulf Coast solitary bee nests are difficult to locate and proxy measurements of fine sandy soil with bare ground and host plant proximity can be used to quantify nesting site availability and habitat quality (Sardinas & Kremen 2014 p. 162). Indeed, a

Gulf Coast solitary female has been recorded digging a burrow in fine sand within the largest patch of honeycomb head in the area on Fort Pickens (*WFREC Bee Video* 2014; Thetford & Miller 2015a p. 13). As such, nesting habitats- open sandy areas in landward dunes near and within stands of honeycomb head- are sufficiently known to provide a basis for the designation of critical habitat and management actions.

Host Plant

Coastal Plain honeycomb head is one of only three species in the genus *Balduina* (family Asteraceae) (Parker & Jones 1975 p. 355). It is found throughout Florida, southeastern Georgia, along the southern coast of Alabama, and the southeast coast of Mississippi (Cane et al. 1997 p. 243) on dry sandy and acidic soil along rivers and on shallow dunes of the Gulf Coast (Parker & Jones 1975 p. 355). The plant has a tap root system and association with mycorrhizal fungi (Anderson & Menges 1997 pp. 944–945). The Coastal Plain honeycomb head is biennial in that it is a small rosette in the first year and in the second year grows to 2-3 feet tall with 1-20 floral heads of eight rayed flowers with a central head of disk flowers, blooming from late August to October (Parker & Jones 1975 p. 359; Florida Native Plant Society 2013 pp. 1–2). One of its two congeners, purpledisk honeycomb head (*Balduina atropurpurea*), is a Florida state endangered species (Florida Department of Agriculture and Consumer Services 2018).

The Coastal Plain honeycomb head is the only known pollen host of the Gulf Coast solitary bee (Cane et al. 1996 p. 238); it is possible the bee also gathers nectar from closely related plants in the genus *Chrysopsis spp.* but this is anecdotal and uncertain and the honeycomb head remains its only known pollen source (Thetford & Miller 2015 p. 12). The Gulf Coast solitary bee is only found where the honeycomb head is abundant (Hunsberger 2013 p. 38).

Despite the bee's dependence on the honeycomb head, the plant is visited by a diverse group of bees; Cane et al. (1997 p. 245) observed 12 bee species from eight genera, including the non-native honey bee, *Apis mellifera*. As the Coastal Plain honeycomb head is self-incompatible (Parker & Jones 1975 p. 357), these other bee visitors probably provide some pollination for the plant. However, the listed bee visitors are polylectic, or generalist, pollinators that collect pollen and nectar from a wide variety of plant species, reducing fidelity and efficacy. Non-native pollinators visit common, weedy plants and can increase the seed set of invasive plants that outcompete the honeycomb head (Barthell et al. 2001 p. 1874; Aizen et al. 2014 pp. 324–325). At the time of description in 1996, the Gulf Coast solitary bee was the most abundant visitor to the honeycomb head; because of this and its fidelity to the plant, it has been a key pollinator of the Coastal Plain honeycomb head (Cane et al. 1997 p. 245).

The Coastal Plain honeycomb head is found in moderately disturbed habitats; specifically, the plant prefers sandy soils not subjected to persistent flooding or soil shifting but also grows near wash-over sand flats with some disturbance (Hunsberger 2013 p. 40). Periodic storms, such as hurricanes, create openings in vegetation, stop forest encroachment, and, as a result, allow for more opportunistic species, like the Coastal Plain honeycomb head, to take hold and provide habitat for native bees (Cane 1997 p. 74). On the other hand, while the honeycomb head will establish is swales, immature plants experience high mortality with excessive flooding in these areas (Hunsberger 2013 p. 70). Thus, the honeycomb head evolved with periodic but not frequent disturbance caused by storms.

Low intensity fires are also periodic disturbances in these xeric ecosystems, creating bare ground openings in vegetation, preferred by the honeycomb head and the bee (Hunsberger 2013 p. 41) as well as a potential pulse of nutrients in the acidic soil (Anderson & Menges 1997 p. 945). The Coastal

Plain honeycomb head is fire adapted but may require recolonization from nearby populations or presence in the seedbank, as one study found that first year rosettes did not survive control burns but reestablished on the burn site from seed (Anderson & Menges 1997 p. 944). Natural fire frequency in these and similar ecosystems is around 15-40 years and considered moderate to infrequent (Stephens & Quintana-Ascencio 2015 p. 1979).

Historic and Current Distribution

The Gulf Coast solitary bee is narrowly distributed along the northern shore of the Gulf of Mexico and extended linearly from Horn Island in eastern Mississippi to St. Andrew's Bay in northwestern Florida (Cane et al. 1997 p. 243). It has been found in Jackson County, MS; Mobile and Baldwin Counties, AL; and Escambia, Okaloosa, Walton, and Bay Counties in Florida. Despite extensive surveys for the bee throughout the region, even within dense patches of its host plant, the bee was only found in sites within 1-2 km of the coast in 1996, when it was described (Cane et al. 1997 p. 243). Further, the Gulf Coast solitary bee was not found on small barrier islands containing its host plant, such as Petit Bois Island in Mississippi, nor on islands or areas without the honeycomb head (Dauphin Island, Alabama and Crooked Islands, and Shell Islands, Florida) (Cane et al. 1997 p. 243).

The Gulf Coast solitary bee was found in only 15 sites in 1993-1994 (Table 1 and Figure 1). Cane et al. (1997 p. 243) estimated the area of the Gulf Coast solitary bee's range at only 100 km^2. When first described, the bee was found in the following locations (Cane et al. 1997 pp. 240–243): one site in Mississippi near "the horseshoe" and the Ranger Station on Horn Island of the Gulf Islands National Seashore; three sites in Alabama at Bon Secour National Wildlife Refuge, Romar Beach, and Fort Morgan State Park; and 11 sites in Florida: Perdido Key State Recreation Area, Big Lagoon State Recreation Area, Fort Pickens of the Gulf Islands National Seashore, Pensacola Beach on Santa Rosa Island, East entry of and near Radar Site at Eglin Air Force Base on Santa Rosa Island, Henderson Beach, Topsail Hill, Blue Mountain Beach, Grayton Beach State Recreation Area, and St. Andrews State Park.

When first described, the Gulf Coast solitary was only found in protected areas and already lost to development in portions of its dune habitat that contained its host plant or other suitable habitat features and for example, in 1997 it was already extirpated from Romar Beach in Alabama due to housing construction (Cane 1997 p. 74). To the petitioner's knowledge, the Gulf Coast solitary bee has not been surveyed outside of Florida since 1997, and thus its status in the one site in Mississippi and two sites in Alabama described in 1994 and 1997 is unknown. Due to the threats outlined below being common to the entire Northern Gulf Coast, it is likely that the Gulf Coast solitary bee has experienced and continues to experience similar threats to its existence in these areas, such as climate change induced sea level rise and increase storm surges and pesticide spraying. Further, any populations of the Gulf Coast solitary bee in Mississippi and Alabama are likely to be in low abundances and experiencing the threat of small and isolated populations, such as inbreeding depression. Any conservation of the bee in Mississippi and Alabama will require enhancing connectivity between populations throughout its range, a management action that can only be accomplished by first listing the Gulf Coast solitary bee as an endangered species under the federal ESA.

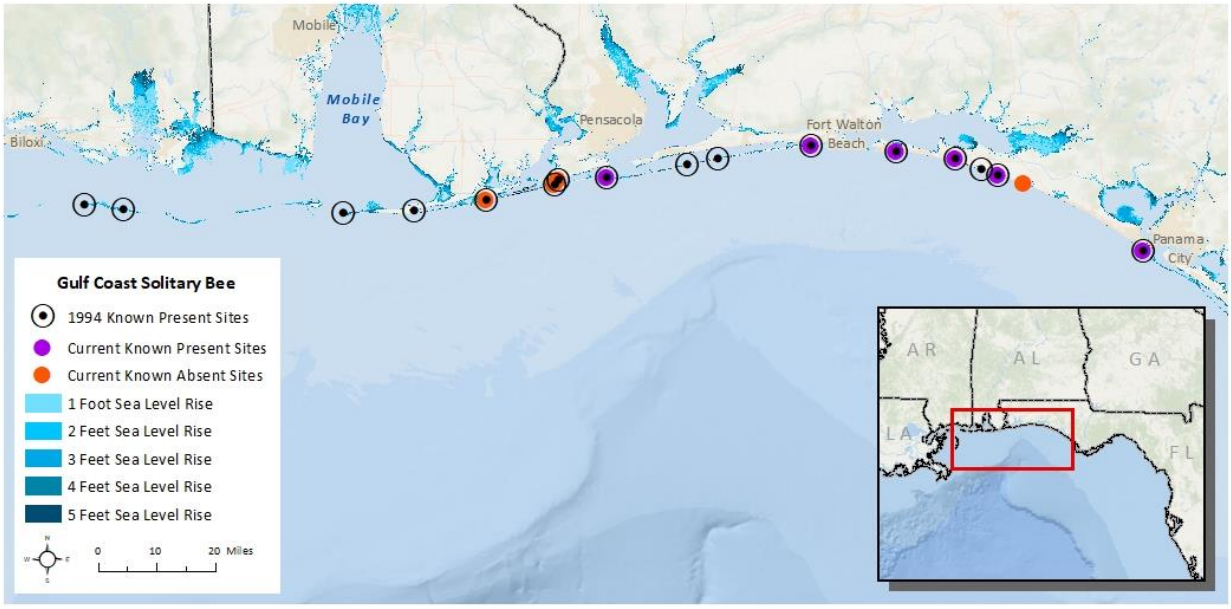


Figure 1. Map of historic and current distribution of the Gulf Coast solitary bee. Purple shaded sites are those that are currently known to be extant and orange shaded sites are those that are confirmed extirpated. Sea level rise data were derived from National Oceanic and Atmospheric Association Sea Level Rise Viewer: https://coast.noaa.gov/slr.

The Gulf Coast solitary bee's presence depends greatly on the number and size of Coastal Plain honeycomb head patches and, in turn, the plant is influenced by local habitat features and surrounding plant communities. In 2011 and 2012, the honeycomb head was nearly four times more dense in coastal mainland sites compared to the barrier islands, leading to a corresponding distribution of the Gulf Coast solitary bee at 20 times greater density in coastal mainland sites than barrier islands in 2012 (Hunsberger 2013 pp. 33, 37–38). Within coastal mainland areas, the bees were also less likely to be found in habitats with dense vegetation, even those with the honeycomb head growing between dense shrubs, such as at St. Andrews and Big Lagoon State Parks (Hunsberger 2013 p. 38), most likely as a result of the lack of open sand nesting habitat.

The bees that were found on the barrier island sites in 2012 were present in very low abundance: no bees were detected in established monitoring survey transects on Perdido Key and Fort Pickens units of the Gulf Islands National Seashore island or sites on Santa Rose Island except for three individuals seen at the Eglin Air Force Base sites on Santa Rosa Island (Hunsberger 2013 p. 33,44). On the coastal mainland sites, 44 bees were documented in monitoring transects at all sites except Big Lagoon State Park (Table 1).

Of sites visited in the fall of 2012, the Gulf Coast solitary bee was seen anecdotally in 11 but when sampled systematically via transect, the bee was recorded in six of those sites (Table 1), despite 15 containing the Coastal Plain honeycomb head (Hunsberger 2013 pp. 57–58). The Gulf Coast solitary bee was notably absent from transects in the western portion of its range, such as Fort Pickens and Perdido Key units of the Gulf Islands National Seashore and from Big Lagoon State Park. The absence of the bee from transects indicates that its abundance and detection probability is significantly lower than in 1993-1994; this is made more notable by the fact that only 47 total individuals were found (Table 1).

Table 1. Known Gulf Coast solitary bee populations and abundance surveyed since 1994. Data from Cane et al. (1997 pp. 240–243), Hunsberger (2013 pp. 44–45), and (Thetford & Miller 2015b pp. 3–4). X=presence but not counted, otherwise abundance recorded. BI=Barrier Island; CM=Coastal Mainland; GINS=Gulf Islands National Seashore; UWF=University of West Florida; NS=not searched. *Bee was not recorded in systematic surveys but was seen anecdotally at the site.

Number	State	Location	Site	1994	1997	2012	2014
1	Mississippi	BI	GINS Petit Bois Island	0	NS	NS	NS
2	Mississippi	BI	GINS Horn Island (west-central)	X	NS	NS	NS
3	Alabama	BI	Dauphin Island	0	NS	NS	NS
4	Alabama	BI	Gulf Shores State Park	0	NS	NS	NS
5	Alabama	BI	Ft. Morgan National Monument	X	NS	NS	NS
6	Alabama	BI	Bon Secour National Wildlife Refuge	X	X	NS	NS
7	Alabama	BI	Romar Beach	X	0	NS	NS
8	Florida	BI	Perdido Key State Park	NS	X	0*	NS
9	Florida	BI	GINS Perdido Key Unit	X	X	0*	0
10	Florida	BI	GINS Fort Pickens	X	NS	0*	7
11	Florida	BI	Santa Rosa Island (GINS Battery)	X	X	0*	NS
12	Florida	BI	Santa Rosa Island (UWF)	X	X	0*	NS
13	Florida	BI	Santa Rosa Island (Eglin Airforce Base)	X	NS	3	NS
14	Florida	CM	Big Lagoon State Recreation Area	X	X	0	NS
15	Florida	CM	Henderson Beach State Recreation Area	X	X	14	8
16	Florida	CM	Topsail Hill State Park	X	X	15	16
17	Florida	CM	Grayton Beach State Park	X	X	12	17
18	Florida	CM	Deer Lake State Park	NS	NS	1	0
19	Florida	CM	St. Andrews State Park	X	NS	2	NS
20	Florida	CM	Blue Mountain Beach	X	X	NS	NS

Three sites in Gulf Islands National Seashore, Fort Pickens, Perdido Key, and Santa Rosa Island, were further examined in 2011 and 2012 as a sample of the status of the Gulf Coast solitary bee and Coastal Plain honeycomb head habitat. The Gulf Coast solitary bee was absent from the Santa Rosa unit in both 2011 and 2012 and the density of the bee decreased significantly from 2011 to 2012 (Hunsberger 2013 pp. 67–68). Coastal Plain honeycomb head patch size and flower density decreased significantly from 2011 to 2012, from 13.5 m to 3.0 m and $12/m^2$ to $3/m^2$, respectively (Hunsberger 2013 p. 68). Of the 51 patches of honeycomb head surveyed, the Gulf Coast solitary bee was found at five in 2011 at a density of 99/ha and at only two in 2012 at a density of 3/ha (Hunsberger 2013 p. 68).

Further changes in density of the Gulf Coast solitary bee were assessed in 2013 and in 2014 at Perdido Key and Fort Pickens Units of Gulf Islands National Seashore, Henderson Beach, Topsail, Grayton Beach, and Deer Lake (Thetford & Miller 2015b p. 2, 2015a p. 3 and 5). The bee was found at least once at only 23% of patches sampled (Thetford & Miller 2015a p. 8). No bees were found along transects on

Perdido Key and Deer Lake, while seven, eight, 16, and 17 where found at Fort Pickens, Henderson, Topsail, and Grayton Beaches, respectively in 2014 (Thetford & Miller 2015b pp. 3–4) (Table 1).

Today, wherever the Gulf Coast solitary bee is found it is not abundant. According to occupancy models, even with five visits to one site, a very high number for a native bee survey, there is still a 27% chance the bee will not be detected due to its lack of abundance (Thetford & Miller 2015a p. 8). Unfortunately due to severe hurricanes and lack of funding, there have been no surveys of the bee since 2014 (Miller 2018 p. 1). Nevertheless, there is no question that this bee is extremely rare and has become much more so within the last 25 years since its initial description. During a census of the bee in 1996, Cane (1997 p. 74) did not report exact numbers of the bee but did find males on Coastal Plain honeycomb head flowers at all sites including Bon Secour National Wildlife Refuge in Alabama and in Florida: Grayton Beach, Blue Mountain Beach, Topsail Hill, Pensacola Beach, Henderson Beach, Perdido Key in GINS, Big Lagoon and Perdido Key State Parks. Cane et al. (1997 pp. 240–246) also collected an additional 102 individuals as well as documented multiple foraging females, patrolling males, and as many as three males sleeping per honeycomb head blossom at all sites; this contrasts with the only 47 bees seen in 2012 and 48 in 2014, a shockingly low number for any animal, let alone an insect.

In sum, the Gulf Coast solitary bee was already imperiled at its discovery due to habitat destruction and, as threats have grown, since 2012, the bee has only been seen in 11 sites and sampled from six of the only 20 potential habitat sites within its small range. With the most recent data from 2014, the bee could be extirpated from two more sites, Deer Lake State Park and the Perdido Key Unit of GINS, taking it down to four confirmed fragmented populations and likely at very low abundances (Table 1). Worse, as this petition describes, those few small Gulf Coast solitary bee populations are greatly imperiled by a variety of threats and need protection under the ESA to avoid extinction.

Conservation Status and Warranted ESA Protection

The Gulf Coast solitary bee is a rare species that, even when first described by Cane, was declared likely endangered as a result of habitat loss and fragmentation (Cane 1997 p. 74; Hunsberger 2013 pp. 79–80) . The threats of habitat loss and fragmentation are now exacerbated by the threat of climate change and pesticides, as the populations of the bee are so isolated that loss of one population will likely result first in local extinction, as re-colonization is unlikely (Hunsberger 2013 p. 81), and then in species extinction. Any hope for the bee's long term existence in the face of climate change will likely be reintroduction or assisted migration into host plant patches further inland (Hunsberger 2013 p. 82), protection only likely if those areas are designated as critical habitat and managed for the Gulf Coast solitary bee once it is listed as an endangered species under the ESA. Due to its very narrow range and habitat requirements, monolectic behavior, and imminent threats to its existence, the Gulf Coast solitary bee fully meets the definition of endangered under the ESA.

The Gulf Coast solitary bee has been recognized as imperiled or needing protection by international, state, and local entities. It has a NatureServe ranking of G1 or critically imperiled from 2007 and all known occurrences may be in danger from development and hurricanes (NatureServe 2018 p. 1). According to NatureServe, as of 2007, the bee is extirpated or likely extirpated from Choctawhatchee Bay and Pensacola Bay (NatureServe 2018 p. 2). The Gulf Coast solitary bee is state ranked as S1/S2, or critically imperiled/imperiled in Florida because of extreme rarity or vulnerability to

extinction due to some natural or man-made factor by the Florida Natural Areas Inventory; however, it is not listed as a Florida Endangered Species or Species of Special Concern so is not formally protected by the state of Florida (Florida Natural Areas Inventory 2016 p. 24). The University of Florida also has called for conservation efforts for the bee (Lyons et al. 2015 p. 3).

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 doing so, 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) (2012). 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, species that are "likely to become endangered species within the foreseeable future" and are listed for protection pursuant to section 4 of the ESA. 16 U.S.C. § 1532(6), 1532(20), 1533.

The ESA states that a species shall be determined to be endangered or threatened based on any one of five factors (16 U.S.C. § 1533 (a)(1)): 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. The Gulf Coast solitary bee's most significant known imperilment is caused by factors one, four, and five. The third factor, the threat of "disease or predation," specifically disease from non-native honey bees, is a likely threat. Also, while the bee itself is not overutilized for commercial, recreational, scientific, or educational purposes, its habitat is significantly overutilized for commercial and recreational purposes. Thus, the Gulf Coast solitary bee warrants protection under the Act and a prompt decision to move forward with listing the Gulf Coast solitary bee based on this petition is required to ensure that protective measures are put in place and that the bee does not go extinct.

Threats

The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

Climate Change

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 further sea level rise, increased incidence of severe weather events, and loss of ecosystems (Intergovernmental Panel on Climate Change 2018 p. 4,8). Sea levels will increase between 1-2.5 feet by 2100 even without further emissions. This will expose low-laying coastal areas to saltwater intrusion and flooding (Intergovernmental Panel on Climate Change 2018 p. 5,10).

Using species listed as vulnerable by the Florida Natural Areas Inventory (FNAI) and applying an index based on research and expert opinion to measure vulnerability to climate change, sea level rise, and land-use change, Reece et al. (2013 p. 4) identified the Gulf Coast solitary bee as a species highly likely to be extinct by 2100 with a 0.93 (out of 1.00) vulnerability score. Thus, the entire range of the Gulf Coast solitary bee will be especially vulnerable to climatic changes in the near future and the combination of threats from development, sea level rise, increase incidence of severe storms and heavy precipitation events will result in habitat loss and fragmentation and ultimately the extinction of the bee unless it is protected and provided critical habitat under the ESA.

Increase Incidence of Severe Storms and Precipitation

Forty years ago, Caribbean hurricanes occurred in the region of the Gulf Coast solitary bee's habitat at a frequency of every six to 21 years (Cane 1997 p. 73). In 1995, hurricane Opal, a category 3 storm, brought 75-115 mph winds, 5-10 inches of rain, and tidal surges of 5-14 feet, inundating back dunes and cutting through barrier island dunes across the bee's range (Cane 1997 p. 73). As the bee and its habitat have evolved with this type of typical tropical storm, surveys one year post hurricane revealed resting males at all sites (Cane 1997 p. 74). However, while tropical cyclones along the northern Gulf Coast were relatively frequent over the last century, storm surges that breached the fore dunes were not common until the last couple of decades, and they are now eliminating dunes in the area (Pries et al. 2008 p. 168). Climate change has already increased storm frequency and intensity over the last 30 years and will continue to do so into the future, specifically in the Gulf Coast solitary bee's habitat (Emanuel 2005 p. 687; Costanza et al. 2016 p. 77).

Hurricane Ivan occurred in 2004 and was a category 3 at landfall that produced > 3.0 m (9.8 ft) storm surges, making it one of the most destructive storms in 100 years only to be followed by hurricane Dennis in 2005 that produced a higher storm surge at > 3.7 m (12.1 ft) (Pries et al. 2008 pp. 169–170). Ivan completely eliminated 71.9% of the foredunes and 19.3% of the secondary dunes (42.1% of smaller secondary dunes and 14.8% of larger secondary dunes), with hurricane Dennis causing additional loss of dunes (Pries et al. 2008 pp. 171–172). This resulted in smaller secondary dunes with less area that were separated by increased distances along Santa Rosa Island where the Gulf Coast solitary bee lives. Furthermore, dune loss after hurricanes was correlated with prior dune size and presence of foredunes (Pries et al. 2008 p. 172), indicating that increased frequency in storms will result in disproportionate dune loss; indeed, researchers believe that dunes once dominated by normal wind and wave activity are shifting to a state in which frequent storm disturbance dictates dune structure and vegetation communities (Pries et al. 2008 p. 174). Thus, in combination with sea level rise (see below), storm surges are likely to result in further loss of secondary dunes, wiping out at least the barrier island portion of the Gulf Coast solitary bee's habitat in the near future.

At the currently predicted warming of 1.5°C by 2030-2052, which is conservative, temperature and precipitation extremes will be exacerbated and heavy precipitation events more frequent in eastern North America (Intergovernmental Panel on Climate Change 2018 pp. 8–10). For the northern Gulf Coast specifically in the Gulf Coast solitary bee's habitat, climate models project an 87-106% increase in precipitation in fall, during the bee's activity period, through this century (Costanza et al. 2016 p. 77). The drastic reduction in the Gulf Coast solitary bee abundance from 2011 and 2012 happened during a time of fluctuating precipitation. While 2011 saw below average precipitation, 2012 had two tropical

storms in June, the hurricane Issac in August and September, and above average rainfall compared to the previous 30 year mean, both daily and total (Hunsberger 2013 p. 69).

In 2012, the Coastal Plain honeycomb head that established in the dune swales died before producing flowers because of increased incidence of rainfall and tropical storms that flooded the swales frequently (Hunsberger 2013 p. 70). Since 2014, frequent and severe rainfall events and hurricanes have prevented further surveying of the Gulf Coast solitary bee because access to its habitat, including roads, have been washed out due to flooding (Thetford & Miller 2019).

Moderate disturbance that creates openings in vegetation but that does not reshape or flood the secondary or landward dunes is required to ensure interannual reliability of large, dense patches of Coastal Plain honeycomb head needed by the Gulf Coast solitary bee. The Gulf Coast solitary bee will exploit patches of the honeycomb head on the periphery of swales, but not in a wet year (Thetford & Miller 2015a p. 9), greatly reducing overall habitat utilized by the bee including the quantity of pollen provisions available for reproduction, as they require large patches of honeycomb head. Thus, increased severity and frequency of rainfall and tropical storms caused by climate change directly reduces the habitat and food resources available for reproduction and survival of the Gulf Coast solitary bee.

Sea Level Rise

The Gulf Coast solitary bee is more common on coastal mainland sites than barrier islands, where it is found only on wide swaths of land. Furthermore, as the bee requires open ground for nesting, it is limited to coastal areas not overgrown with vegetation or developed. As a result, the Gulf Coast solitary bee currently only survives on a narrow strip of land about 110-475 meters from the shoreline (Hunsberger 2013 p. 41), habitat clearly impacted by sea levels. Sea level rise is not only a longer term threat faced by the bee but current sea level rise is occurring at a rate of 2.36 mm/year in its Florida habitat, 3.61 mm/year in Alabama habitat, and 4.56 mm/year in Mississippi habitat, if they are still extant (National Oceanic and Atmospheric Administration 2018). That kind of inundation not only water logs its potential nesting habitat but salt water intrusion kills plants like the Coastal Plain honeycomb head (Xiao et al. 2018 p. 217), reducing the bee's food source.

Until recently, shorelines were relatively stable for the past 6,000 years and did not experience the rates of sea level rise predicted for the coming century (Donoghue 2011 p. 19). Globally, sea level rise averaged 1.7 mm/year over the last century but has risen to 3.1 mm/year in the last 15 years and while the shoreline of the United States is lost at about one m/year generally, the north Gulf Coast is retreating at almost double the pace at 1.8 m/year (5.9 ft/year), which hastens the inundation caused by sea level rise (Donoghue 2011 p. 18). Up to eight percent of the Gulf Coast of Mississippi, Alabama, and Florida is expected to be inundated due to one to six feet sea level rises (National Oceanic and Atmospheric Administration 2018). Using a mid-range climatic model for future sea level rise, it is predicted that Florida will experience a one meter (3.3 ft) rise over the next century that inundates 10% of the land surface, including the barrier islands and coastal mainland that serve as the Gulf Coast solitary bee's current habitat (Figure 2) (Donoghue 2011 pp. 27–28).

The negative impacts of sea level rise on the Gulf Coast solitary bee and its habitat are exacerbated by sediment dredging that decreases land formation in the Gulf. In general, barrier islands can regain land from upriver sediment deposition, but the sediment supply has greatly declined due to dredging for ship navigational channel enlargement (Lucas & Carter 2010 p. 1147). Due to sea level rise

and artificial channel creation that diverts sediment, the Mississippi barrier islands have become smaller in size over time since 1850 (Lucas & Carter 2010 p. 1142). Horn Island is the sole location in Mississippi that harbored a Gulf Coast solitary bee population historically but the landward dunes, or the bee's habitat, have decreased by more than half since 1978 and are now only 2% of the island (Lucas & Carter 2010 p. 1146). The resultant smaller islands are then exposed to salt water encroachment and altered water tables and soil moistures (Lucas & Carter 2010 p. 1147) which can greatly impact the Gulf Coast solitary bee's nesting habitat as well as the ability of the Coastal Plain Honeycomb head to survive.

The synergy of sea level rise and storm surge increases the negative impacts and vulnerability of human and natural areas to flooding. The combination of tropical storms and sea level rise is anticipated to cause inundation on barrier islands and coastal areas of Mississippi, Alabama, and Florida in a non-linear way, with maximum storm surge flooding increasing by more than the applied sea level rise and occurring earlier and for longer periods of time (Bilskie et al. 2016 pp. 190–191). Higher sea level rise levels are associated with continued carbon emissions and the intermediate to high sea level rise projections are, in turn, associated with significant reductions in dune heights, increases in shoreline erosion, and inundation of barrier islands and coastal bay areas of all three states (Bilskie et al. 2016 p. 184). As described above, storm surge eliminates dunes and reduces dune height but in the presence of sea level rise, barrier islands are more likely to overtop and coastal mainland are more likely to be subjected to a further one meter increase in water levels at inundation (Bilskie et al. 2016 p. 190).

In sum, whether taken as separate threats or, more accurately, as synergistic threats, climate change is increasing frequency and severity of storms as well as sea levels and threatening the entire habitat of the Gulf Coast solitary bee. Further, land use change models have shown increased urban sprawl with sea level rise and a corresponding reduction in natural areas (Bilskie et al. 2016 p. 191). These are threats that can be minimized and abated by reductions in carbon emissions, as models show that sea level rise will increase 138% under high emission scenarios and an increase of 35% between intermediate-low and intermediate-high scenarios in the bee's habitat (Bilskie et al. 2016 p. 185). Regardless, sea level rise will continue due to past emissions and the bee requires habitat restoration and creation further inland in areas of Coastal Plain honeycomb head; if the Gulf Coast solitary bee does not naturally colonize created habitat areas, assisted migration may be required. The kind of extensive management needed to conserve this bee will only be implemented if the bee is listed as an endangered species under the ESA and provided critical habitat.

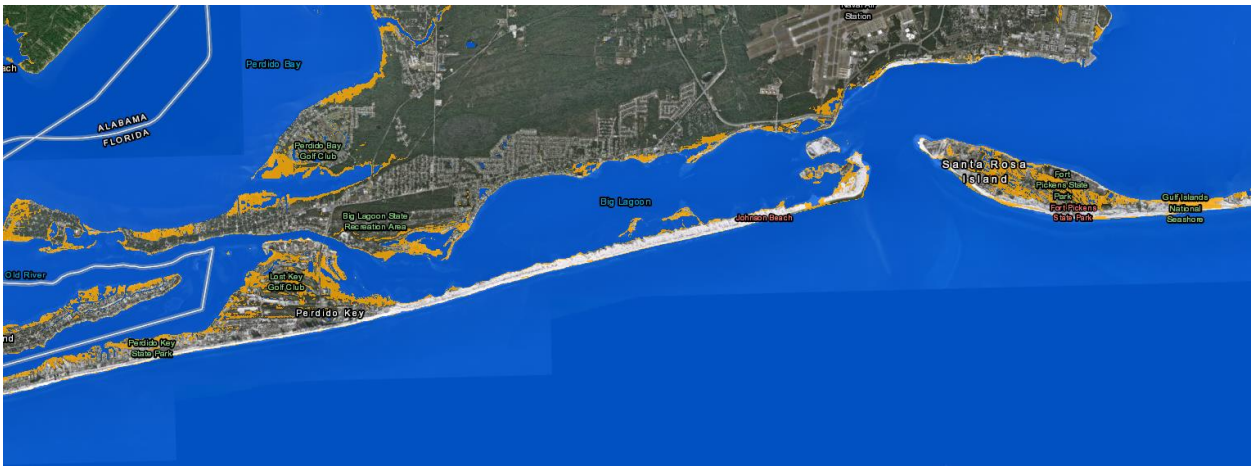


Figure 2. Modeled sea level rise in a portion of the Gulf Coast solitary bee's range. Orange indicates the water level with a three foot sea level rise. As indicated in the text, using a mid-range climatic model, it is predicted that Florida will experience a one meter (3.3 ft) rise over the next century. Modeled using the National Oceanic and Atmospheric Association Sea Level Rise Viewer: https://coast.noaa.gov/slr.

Phenology

Maximum temperatures are expect to rise in the Gulf Coast solitary bee's habitat by 1-4°C, with minimum temperatures increasing up to 6°C, depending on the climate change scenario examined (Costanza et al. 2016 pp. 79–80), leading to potential phenological mismatches between the bee and Coastal plain honeycomb head's emergence. The Gulf Coast solitary bee's primary habitat consists of intermediately disturbed landward dunes and areas on the periphery of swales; this suggests that the bee chooses sites due to the relative stability of its floral host plant as well as undisturbed nesting habitat. Bees in general are found in a patchy distribution near annually dependable floral resources or host plants (Minckley et al. 1999 pp. 139–140). With climate change, the interannual reliability of Coastal Plain honeycomb head will be compromised, as was seen from 2011 to 2012, resulting in less abundance of and less predictability of habitat and resources, leading to smaller bee populations (Hunsberger 2013 p. 71).

Since the Gulf Coast solitary bee adult emergence in late September and early October coincides with the blooming of the Coast Plain honeycomb head, any change in climate that alters the bee's emergence timing in a different way than the plant's with result in mismatch and a lower bee population. As noted above, maximum storm surge flooding is expected to occur earlier and for longer periods of time (Bilskie et al. 2016 pp. 190–191), which could kill patches of honeycomb head prior to bee emergence. As the Coastal Plain honeycomb head has a short flowering period, any delay or acceleration in emergence due to climate change can cause the Gulf Coast solitary bee to miss the peak blooming and consequently vital pollen resources needed to provision their offspring. Plant and bee phenological cues are often a combination of temperature and precipitation but very likely to respond at different rates to climate change (CaraDonna et al. 2018 p. 9), with solitary bees also responding to body size as an emergence cue (Schenk et al. 2018 p. 6).

This life cycle pattern may create a temporal fragmentation if different habitats experience different rainfall patterns, leading to different timing in emergence between Gulf Coast solitary bee

populations. Temporal fragmentation reduces gene flow and increases habitat isolation (Danforth 1999 p. 1992), exacerbating inbreeding depression caused by habitat loss and fragmentation.

Finally, with increasing temperatures, climate change is likely to directly negatively impact the Gulf Coast solitary bee via reduction in mating, reproductive success, and survival. In one of the few experiments on climate change impacts on a solitary bee, males and female bees emerged later but at different rates as a result of a warming of 1.8-2.6°C compared to controls (CaraDonna et al. 2018 pp. 5–6), most likely due to insufficient winter cooling time needed for development (CaraDonna et al. 2018 pp. 7–8). Further, experimental warming led to a 39-55% reduction in body fat in the solitary bee and 25-70% mortality above bees reared in control temperatures (CaraDonna et al. 2018 p. 7). Thus with a small increase in temperature, such as 1.5°C reached by 2030-2052 based on current climate projections (Intergovernmental Panel on Climate Change 2018 p. 4), the Gulf Coast solitary bee is likely to experience high mortality, phenological mismatch, and reduced population viability. Climate change is an imminent threat to the Gulf Coast solitary bee's survival and due to its already narrow range, it is unlikely able to adapt to global warming.

Oil drilling and spills in the Gulf of Mexico

Crude oil production in the Gulf of Mexico reached a record high of 1.65 million barrels per day in 2017 and is expected to have increased to 1.7 in 2018 and 1.8 million barrels per day in 2019, both via increases in production and addition of projects coming online (U.S. Energy Information Administration (EIA) 2018 p. 1). There have been 13 oil spills in the Gulf of Mexico since 1970 ranging from 0.5 million gallons to the largest 2010 Deepwater Horizon well blowout that released 134 million gallons of oil into the Gulf (National Oceanic and Atmospheric Administration 2019 p. 1). While even small oil spills can result in extreme environmental damage (National Oceanic and Atmospheric Administration 2019 p. 1), the Deepwater Horizon spill affected more than 2100 km of shoreline in Louisiana, Mississippi, Alabama, and Florida, causing widespread contamination of coastal habitats over half of which were beaches (Beyer et al. 2016 p. 2,20). Oil toxicity has been observed in coastal invertebrates and vertebrates, causing reduced growth and increased mortality rates (Beyer et al. 2016 p. 26,31). With the expected increase in oil production in the gulf and concomitant climate changed induced inundation and loss of foredunes, the Gulf Coast solitary bee's habitat is threatened by oil drilling and resultant spills.

Pesticide spraying

Private and public land managers in Florida counties in which the Gulf Coast solitary bee is found regularly apply pesticides to standing water to control mosquito larvae using aerial and road side spraying, which leaves all bee populations vulnerable to this threat (Hunsberger 2013 p. 82). The biting stable fly, *Stomoxys calcitrans*, is found in and around the Gulf Coast solitary bee's range and is considered a pest. Diurnal broad-spectrum insecticide is sprayed aerially to control the stable fly over the honeycomb head blooms during active periods of the bee (Cane 1997 p. 74). Indeed, demand by residents and visitors to spray such insecticides for biting flies has been implicated in the loss of the bee at one beach park despite dense patches of its host plant present at the site (Cane 2005 p. 121).

Development for beachfront recreation, such as condos and commercial buildings, and the insecticide spray that accompanies such development, has led to the extirpation of the Gulf Coast solitary bee from sections of its formerly continuous habitat (Cane 2005 p. 121). For example, Deer Lake

was once home to the Gulf Coast solitary bee but due to recent housing development around the area and the accompanying insecticide spraying, the bee has not been seen at the site since 2012, despite the presence of dense patches of the honeycomb head (Thetford & Miller 2019).

Okaloosa County, which houses Santa Rosa Island, operates a county-wide pesticide program that includes all areas outside of State Parks and Air Force Bases (Okaloosa County 2015a p. 1). Okaloosa County has around 30 of the 80 species of mosquitoes in Florida, including the day flying Asian Tiger Mosquito (Okaloosa County 2015a pp. 1–2). The County website indicates that spraying only occurs as needed when mosquito populations meet State criteria, yet also that "historical data indicates that at some point in the spring and fall, surveillance data meets the minimum requirements each week so treatment is expected (Okaloosa County 2015b p. 2)." The County primarily uses Permethrin as an aerial adulticide (Okaloosa County 2015b p. 7) which is extremely toxic to bees and results in severe losses of bees present at time of spray (Cornell Cooperative Extension 1993a p. 3).

National and State parks on the Gulf Coast have general nuisance animal (primarily mosquito) control plans that are detrimental to the Gulf Coast solitary bee. While aerial spraying is illegal in parks, managers use larvicides, adulticides, and ground fog sprays when they determine conditions warrant arthropod control. At Perdido Key and Big Lagoon State Parks, where the Gulf Coast solitary bee has not been recorded since 1996, pesticides are used to control ground dwelling invasive ants (State of Florida 2018 p. 100), which could be detrimental to the bee considering it nests in the soil. Insecticides to control mosquitos are also used at Grayton Beach and St. Andrews Beach State Parks, despite the parks' management plans including some language about protecting the Gulf Coast solitary bee (State of Florida 2013b p. 47, 2016a p. 47).

As such, there are very few preexisting regulations that limit pesticide spraying to account for imperiled insects if they are not listed. Pesticide usage in these sensitive areas can decimate bee populations when used during the active feeding time of these insects. Arthropod control must be regulated to avoid insecticide use during periods of Gulf Coast solitary bee feeding in September and October and additionally avoid spraying herbicide on and near the honeycomb head host plant when it is in bloom. Control of invasive or unwanted vegetation involves use of herbicide in the Gulf Coast solitary bee's habitat (State of Florida 2013a p. 39, 2016b p. 45), including the spraying of glyphosate (State of Florida 2018 p. 97). Aside from killing the Coastal Plain honeycomb head, the bee's food source, use of herbicide could harm the bee directly. Specifically, exposure to glyphosate was recently found to alter bee gut microbiota and resulted in increased susceptibility to pathogens and subsequent increased mortality (Motta et al. 2018 p. 3).

The threat of insecticide spraying is anticipated to worsen with increased incidence and severity of storms and precipitation events, as the incidence mosquito control increases the weeks following storm events (Center for Disease Control and Prevention 2018a p. 1), which occur frequently during the active period of the Gulf Coast solitary bee in September and October. In particular, the insecticide Naled is frequently used to control mosquitos post-hurricane (Center for Disease Control and Prevention 2018b p. 1). Naled is highly toxic to bees (Cornell Cooperative Extension 1993b p. 3). Thus, with the increase frequency and severity of storms, more water will remain post-storm causing the increase of insecticide use as climate change worsens. As a result, the Gulf Coast solitary bee is threatened with extinction by the synergy of climate change and pesticide spraying. Listing the Gulf Coast solitary bee as an endangered species is the only way these threats will be addressed or mitigated.

Recreation

Florida State Parks had over 31 million state residents visit in 2016, with over two million visiting the parks in which the Gulf Coast solitary bee resides (Baxley 2016 p. 1,6). Recreation on sandy ecosystems, especially dune ecosystems, can cause trampling and erosion which can cause increased mortality of vegetation (Defeo et al. 2009 p. 3), such as the Coastal Plain honeycomb head upon which the Gulf Coast solitary bee depends. Compaction of soil caused by humans walking over the surface of the sand can also destroy burrows or kill invertebrates (Defeo et al. 2009 p. 3), in some cases significantly decreasing the number of larval burrows created by ground nesting insects (Cornelisse & Hafernik 2009 p. 498). Thus, with the large number of annual visitors to the Gulf Coast solitary bee's habitats and the impacts of trampling on ground nesting insects and sand dwelling plants, recreation is no doubt negatively impacting the bee and its host plant in its remaining range.

Urbanization, Habitat Fragmentation, and Reduced Gene Flow

Urbanization

Urbanization is a current and imminent threat to the Gulf Coast solitary bee. The bee's remaining known range occurs in Florida, which has grown by nearly 2.5 million people (13%) from 2010 to 2018 (United States Census Bureau 2018b p. 5). The bee has been found in Florida counties which, combined, have increased in population by nearly 90,000 from 2010 to 2018 (United States Census Bureau 2018a) on top of a 39% increase from 1970 to 2010 (National Oceanic and Atmospheric Administration 2013 p. 4). The increased human population has resulted in large-scale land use change. These coastal shoreline counties have added urban land at a rate of one football field every 10 minutes, and two-thirds of this growth was in low density sprawl (National Oceanic and Atmospheric Administration 2013 p. 6).

The majority of the increased urbanization has occurred in the bee's habitat, along the coast in its entire range of Florida, Mississippi, and Alabama (Figure 3). The average population density of coastal shoreline counties is 446 pers/mi^2 compared to the US average of 105 pers/mi^2 (National Oceanic and Atmospheric Administration 2013 p. 5). Population growth and development is expected to increase in the Gulf Coast solitary bee's habitat with a further six percent of the ecosystem converted to development by 2050 and 12% by 2100 (Costanza et al. 2016 p. 81).

Construction of housing and buildings near the shore and on barrier islands directly destroys the dune habitat needed by both the honeycomb head and the bee. Beachfront housing developing and associated commercial sprawl in the Gulf Coast solitary bee's range is created by flattening of the bee's primary nesting habitat, the landward dunes, and as a result has driven out the bee where development takes place (Cane 2005 p. 121). This has been a concern for the Gulf Coast solitary bee since it was described in 1997 and has led to the extirpation of the bee from sections of its formerly continuous habitat (Cane 1997 p. 74, 2005 p. 121).

Coastal development results in compaction of dune soil, decimates native vegetation, introduces exotic plants and animals, and results in insecticide spraying. In addition, development exacerbates the threat of severe storms, as it impacts dune regeneration and connectivity between habitats, resulting in reduced recolonization post-storm (Pries et al. 2009 p. 848). The Gulf Coast solitary bee is unable to adapt to these changes, Cane (1997 p. 74) observed that after hurricane Opal in 1996

the Gulf Coast solitary bee was found at all previously known sites except Romar Beach in Alabama because the site had been cleared for construction, clearly demonstrating the negative synergistic impact of urbanization.

In general, urbanization results in a reduction of both abundance and diversity of native bees (Cardoso & Gonçalves 2018 p. 2) as well as loss of species richness (Hung et al. 2017 p. 8). Additionally, urbanized ecosystems shift the species community from solitary to social bees (Banaszak-Cibicka & Żmihorski 2012 p. 335; Cardoso & Gonçalves 2018 pp. 3–4) and to more generalist bees (Banaszak-Cibicka & Żmihorski 2012 p. 334; Hung et al. 2017 p. 8). The Gulf Coast solitary bee requires consistent populations of coastal honeycomb head and undisturbed areas of bare soil in order to reproduce, both of which are lost with urban sprawl.

The Gulf Coast solitary bee relies exclusively on the Coastal Plain honeycomb head for nectar and pollen and urbanization results in a direct reduction in abundance of this plant. Degraded habitats in urbanized areas house fewer seedlings of the honeycomb head than intact habitat (Stephens & Quintana-Ascencio 2015 p. 1985). Habitat degradation most likely alters the abundance or composition of seed predators of the honeycomb head, resulting in more seed predation in degraded habitats (Stephens & Quintana-Ascencio 2015 p. 1986). The Gulf Coast solitary bee is found only in a small subset of the honeycomb head's range, thus it is more vulnerable to urbanization.

Fire suppression and subsequent buildup of dense woody vegetation due to urbanization also prevent the bee from moving between honeycomb head patches (Hunsberger 2013 p. 39). As part of a fire adapted ecosystem, the bee benefits from low intensity fires that can increase bare ground and flowering plants by reducing shrubby and hardwood vegetation (Costanza et al. 2016 p. 77). Urbanization is expected to increase in the Gulf Coast solitary bee's habitat with a further six percent of the ecosystem converted to development by 2050 and 12% by 2100, increasing the urban-wildland interface and fire suppression (Costanza et al. 2016 p. 81).

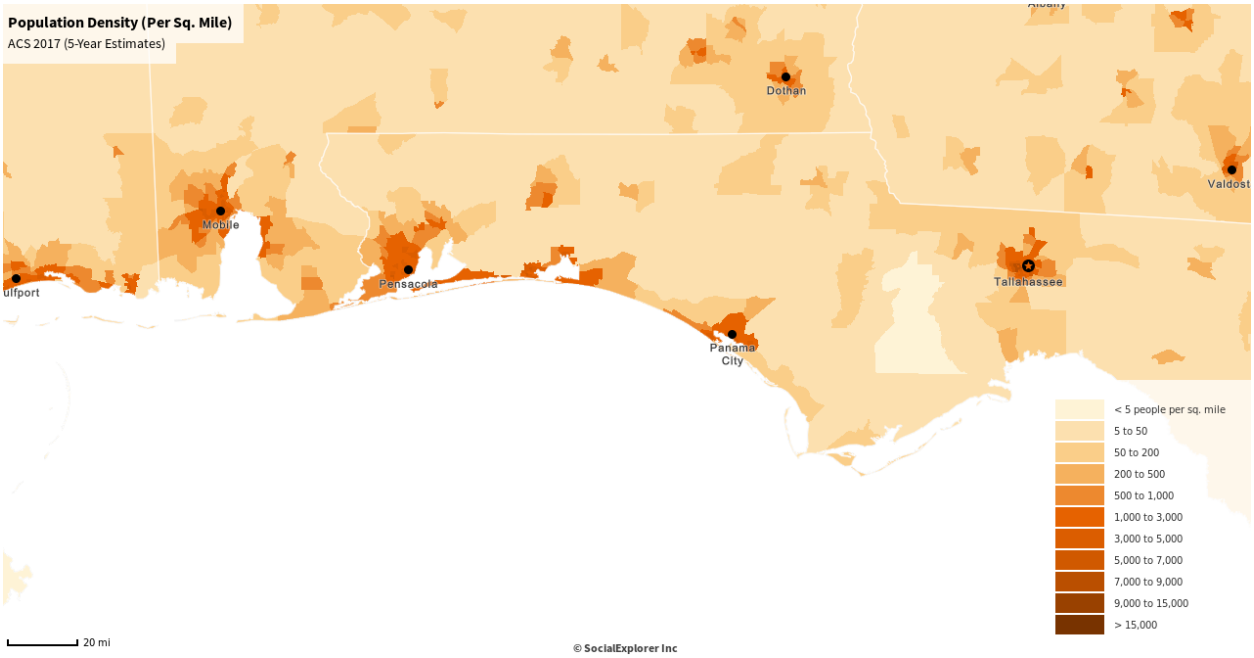


Figure 3. Map of human population density per square mile within the Gulf Coast solitary bee's range.

Habitat Fragmentation

The Gulf Coast solitary bee either exists as a single at risk metapopulation or a series of isolated patchy populations in its entire 100 km^2 range. The bee likely has a maximum foraging range of one km, which is as a dispersal distance proxy. Smaller insects with limited dispersal abilities tend to exist in patchy populations or metapopulations (Franzén & Nilsson 2009 p. 79). Within patchy populations, dispersal between patches, known as patch dynamics, is crucial to the survival of the species (Pulliam 1988 pp. 652–654). Even small habitat patches of lower quality, often known as sinks, and the ability of an individual to disperse to sinks, are of vital importance to the survival of the species as a whole; sinks can act as spill over areas for less competitive bees to establish mating territory and nests (Pulliam 1988 p. 659; Howe et al. 1991 p. 251). Nests in sinks can be as successful as those found in better quality habitat, they are just fewer in number (Franzén & Nilsson 2009 p. 83). The minimum distance between proximate present sites, such as Grayton Beach, Topsail Hill, and Deer Lake Beach is around seven miles, or about 11 km, making it likely that the bees populations are isolated with little or no connectivity.

Urbanization has led to the current severely fragmented habitat and has resulted in the loss of vital population connectivity and habitat throughout the Gulf Coast solitary bee's habitat. With the bee surviving in only remnant protected areas, it is now fragmented and no longer able to maintain metapopulation dynamics, such as the rescue effect allowing for recolonization after storms or other such large disturbances (Cane 2005 p. 121). In addition to urbanization causing fragmentation in the Gulf Coast solitary bee's current known habitat sites, urbanization has resulted in barriers between coastal mainland site and sites with the Coastal Plain honeycomb head further inland. Specifically, roads and buildings as well as the resultant fire suppression and subsequent buildup of dense vegetation prevent the bee from moving between honeycomb head patches (Hunsberger 2013 p. 39).

The Gulf Coast solitary bee is threatened by habitat fragmentation at both the local and regional scale as anthropogenic land use changes and recreation in areas between floral hosts decreases connectivity between floral patches and negatively affects nesting site availability (Cane 2001 p. 4). The bee only uses floral patches greater than 111 m^2 and those with 2.5 plants per m^2 separated by < 20 m (Hunsberger 2013 pp. 44–47). Female bees must complete several foraging bouts between host plants and nests to provision brood cells with sufficient pollen, creating high energetic demands. Solitary bees have reduced fecundity via a reduction in the portion of provisioned brood cells when nesting sites and host plants are too far apart in space, even distances of 300 and 500 m (Zurbuchen et al. 2010a p. 677) and 150 m (Peterson & Roitberg 2006 p. 592). Increased foraging time can decrease the already small number of solitary bee progeny by 50% (Zurbuchen et al. 2010a p. 679) as well as dramatically decrease the total number of nests provisioned (Peterson & Roitberg 2006 p. 592). In addition, the threat of large distances between host plants is compounded by increased exposure of adults to predators and, while adults are away foraging, increased exposure of nests to parasitism (Franzén & Nilsson 2013 p. 1404). Additional costs include poor quality of or less pollen provisioned and lower overwinter survival of offspring and an overproduction of male offspring, as they require smaller pollen provisions (Peterson & Roitberg 2006 p. 593; Zurbuchen et al. 2010a pp. 679-680 and references therein).

The small foraging distance of the Gulf Coast solitary bee could lead to failed reproduction in small or isolated populations of their host plants (Greenleaf et al. 2007 p. 589), this is especially a threat to this monolectic bee that cannot switch host plants when the honeycomb head is scarce or absent (Franzén & Nilsson 2013 p. 1404). As a result, loss of connectivity on both a local and landscape scale is a

key threat to the continued survival of the Gulf Coast solitary bee that is exacerbated by the loss of habitat due to climate change and urbanization.

Loss of Genetic Diversity and Production of Diploid Males

The lack of connectivity between Gulf Coast solitary bee populations results in lower gene flow, or genetic mixing, between metapopulations (Packer et al. 2005 p. 199). This population isolation leads to inbreeding depression (the increased incidence of mating among relatives leading to an increase in homozygosity of deleterious alleles), lower effective population size, diploid male production (results from and exacerbates inbreeding), loss of genetic diversity, and subsequent extinction (Zayed 2009 p. 238; Portman et al. 2018 p. 602). As an example, *Colletes floralis* is a rare, solitary, and ground-nesting bee found on dunes in 12 fragmented patches and is one of the few solitary bees for which population genetics have been tested (Davis et al. 2010 pp. 4923–4924). Genic differentiation between all *C. floralis* populations, save for the two closest, was found to be highly significant, even across short distances, indicating lack of gene flow (Davis et al. 2010 pp. 4927–4928). Areas between habitat patches without preferred sandy nesting substrate, such as urban areas, acted as barriers to gene flow (Davis et al. 2010 p. 4929); despite a foraging and dispersal distance assumed to be 0.4-10 km (Davis et al. 2010 p. 4926).

Inbreeding depression occurs in small populations with no gene flow and is a major threat to population viability (Zayed 2009 p. 244). The mating and sex determination system in bees makes them particularly susceptible to the negative effects of inbreeding depression. Bees are haplodiploid organisms in that haploid males develop from unfertilized eggs while diploid females develop from fertilized eggs (Zayed 2009 p. 239). Diploid males form when females fertilize eggs with sperm that has the same allele at the sex-determination locus; an increase in the same allele is a result of a small and inbred population (Zayed 2009 p. 239). Diploid males are sterile or produce inviable offspring, such as sterile triploid daughters, reducing the already low fecundity in solitary bees (Zayed & Packer 2005 p. 10745; Zayed 2009 p. 242). 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 already endangered haplodiploid solitary bees like the Gulf Coast solitary bee (Zayed & Packer 2005 pp. 10744–10745). Small and genetically depauperate populations are also less able to adapt to changing environmental conditions (Zayed 2009 p. 246); for instance, with less genetic diversity due to reduced gene flow and inbreeding, the Gulf Coast solitary bee will be less likely to adapt to increase in temperatures due to climate change.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization pushes imperiled species towards extinction, especially in conjunction with other threats. It is not known whether overutilization threatens the Gulf Coast solitary bee, but given its limited geographic range and low population numbers, any utilization for commercial, recreational, scientific or educational purposes could pose a serious threat.

Other Natural or Manmade Factors Affecting its Continued Existence

Loss of Pollination Mutualism

Loss of plant-pollination mutualisms due to human activity is an increasing threat to ecosystem integrity across the globe, as biotic pollination is responsible for >90% of flowering plant reproduction (Traveset & Richardson 2014 p. 91; Portman et al. 2018 p. 594). Plant-pollinator mutualisms can become endangered as a result of biological invasions that alter seed set, genetic structure, and population growth of mutualists, such as reduction in the Gulf Coast solitary bee caused by non-native honey bees; climate change that causes phenological mismatch, such as honeycomb head bloom happening before emergence of its bee; and habitat loss and fragmentation that decreases the abundance of the native bee via loss of breeding sites and/or decreased gene flow leading to inbreeding depression that leads to a change in seed set of the plant (Kiers et al. 2010 p. 1460; Traveset & Richardson 2014 p. 101).

Oligolectic pollinators are duly affected by habitat fragmentation both directly via reduction in their own population connectivity and gene flow, but also indirectly through the decrease in host plant density within remnant habitats patches (Hickerson 1998 p. 11). The reduced host plant density and subsequent pollinator abundance results in runaway ecosystem degradation in which self-pollinating plants outcompete host plants and generalist pollinators outcompete specialists, further reducing the populations of both specialist plants and their pollinators (Hickerson 1998 p. 11). The more tightly linked an oligolectic bee is to its pollen hosts, the more susceptible it is to negative population trends in the plant (and vice versa), making monolectic bees, like the Gulf Coast solitary bee, particularly vulnerable due to a failed mutualism (Packer et al. 2005 p. 196).

Non-native honey bees and exploitative competition

As of June 2016, there were over 4,000 registered honey beekeepers in Florida with over 440,000 managed hives (Bustamante et al. 2016 p. 1); Mississippi has 20-30,000 hives in the summer and 80-120,000 in the winter (Mississippi State University Extension 2019 p. 1); and Alabama had 600 registered beekeepers with over 7,000 hives in 2017 (Alabama Living Coop 2017 p. 2). Honey bees displace native bees from preferred high quality forage plants through exploitative competition, higher number of individuals, and the longer activity period during which honey bees forage; because they recruit nest mates to floral resources, honey bees overwhelm other species (Goulson 2003 p. 8; Dupont et al. 2004 p. 307; Thomson 2004 pp. 463–465, 2016 p. 5; Traveset & Richardson 2014 pp. 99–101). A typical honey bee colony pastured for three months collects the equivalent of 110,000 (92,000-300,000 depending on number of bees per hive) native bee pollen provisions (Cane & Tepedino 2017 p. 207). Thus, proximity to honey bee hives and/or presence of hive-dense apiaries forces native bees to forage greater distances on less pollen with a resultant reduction in fitness and, in turn, population (Henry & Rodet 2018 p. 2). As managed honey bees are not native to North America, neither the Gulf Coast solitary bee or its dune habitat has evolved to coexist with honey bees. Competition with honey bees is especially a concern for the Gulf Coast solitary bee which is unable to forage at greater distances or switch host plants.

Africanized honey bees

Africanized honey bees are a hybrid of European (*Apis mellifera ligustica*) and African (*Apis mellifera scutellata*) honey bee subspecies that spread into the Americas after accidental release in

Brazil in the 1950s, making their way up to Texas in 1990, then throughout the southern US (Rabe et al. 2005 p. 307; Harrison et al. 2006 p. 1111; Kono & Kohn 2015 pp. 1–2). Africanized honey bees are documented within the range of the Gulf Coast solitary bee (Florida Department of Agriculture and Consumer Services 2019 p. 1). While few managed European honey bee hives become feral, Africanized honey bees are more likely to swarm and start feral colonies in small cavity locations or underground and are restricted to areas with warmer winter temperatures due to physiological and life history characteristics, making them more prone to invade natural systems (Harrison et al. 2006 pp. 1114–1115; Hodgson et al. 2010 p. 3; Kono & Kohn 2015 p. 10). The expansion of the Africanized honey bees throughout the south could have negatively impacted Gulf Coast solitary bee populations.

A clearly documented trait of Africanized honey bees that differs from European honey bees is their preference for pollen collection over nectar, presumably due to the greater nutrition benefit of pollen for brood production (Harrison et al. 2006 p. 1117). The pollen-collecting behavior of Africanized honey bees negatively impacts the reproductive output of oligolectic bees (Portman et al. 2018 pp. 601–602). As described above, exploitative competition from honey bees forces the Gulf Coast solitary bee to seek other patches of its host plant, which due to habitat fragmentation are sometimes no longer within foraging distance. As such, the Gulf Coast solitary bee can no longer survive where Africanized honey bees dominate and Coastal Plain honeycomb heads are sparse.

Disease or Predation

Disease from honey bees is a threat to the Gulf Coast solitary bee. Several studies have shown that Deformed Wing Virus and Black Queen Cell Virus is transferred from honey bees to bees in other families and also that the viruses replicate in those native bee genera (Tehel et al. 2016 pp. 18–19). As honey bees continue to proliferate throughout the south, the threat of diseases increases for the Gulf Coast solitary bee.

The Inadequacy of Existing Regulatory Mechanisms

There are no existing regulatory mechanisms adequate for protecting the Gulf Coast solitary bee from extinction. To determine which, if any, regulatory mechanisms for the protection of the Gulf Coast solitary bee exist, in the past year, the petitioner sought, received, cataloged, and evaluated both publicly available information and documents obtained from federal and state agencies pursuant to Freedom of Information Act and similar state public records requests.

The gulf coast of the states of Florida, Alabama, and Mississippi are home to great biodiversity and unique coastal ecosystems that deserve protection. These natural and cultural resources are partially protected by the Clean Water Act, the Coastal Barrier Resources Act, and State wildlife preserves/State parks. However, none of these provide the Gulf Coast solitary bee with the protection it needs. Currently, the Gulf Coast solitary bee is listed on NatureServe at G1G2 status (NatureServe 2018 p. 1) meaning this species is imperiled or critically imperiled due to its rarity and other factors, but this designation does not provide any protective regulatory mechanisms. The bee is state ranked as S1/S2, or critically imperiled/imperiled in Florida because of extreme rarity or vulnerability to extinction due to some natural or man-made factor by the Florida Natural Areas Inventory; however, it is not listed as a Florida Endangered Species or Species of Special Concern so is not formally protected by the state of Florida (Florida Natural Areas Inventory 2016 p. 24). Neither the bee nor the Coastal Plain honeycomb

head are listed or formally protected in Alabama or Mississippi. Without ESA protection at the Federal level this species will not be protected from the ongoing threats it faces.

The objective of the Coastal Barrier Resources Act is to "encourage conservation of hurricane-prone, biologically rich coastal barriers" by not subsidizing development in these coastal barriers, especially through flood insurance, which indirectly conserves coastal barrier islands by restricting development (United States Fish and Wildlife Service 2019 p. 1). Despite this restriction of federal support, development on the gulf coast has continued and accelerated in recent decades, and from 1996-2010 the amount of developed land grew at a rate of 17% per year (National Oceanic and Atmospheric Administration 2010 p. 6). Large amounts of coastal habitat have been developed without government restrictions on development, the amount of suitable habitat will continue to diminish. The Act does not provide adequate regulatory mechanisms to protect the Gulf Coast solitary bee.

State park management plans provide protections for four ESA listed mice (St. Andrews's Beach Mouse, Choctawhatchee Beach Mouse, Perdido Key Beach Mouse, and the Alabama Beach Mouse) including: monitoring, protection from exotic predators, reduced light pollution, beach crossovers, and prescribed fire (State of Florida 2007 pp. 7, 32, 34, 2013b pp. 29, 45, 2016a pp. 28–29, 43–44, 2016b p. 58, 2018 pp. 61, 81; National Park Service 2014 p. 173). The critical habitat designations for four ESA listed beach mice partially overlaps with the observed range of the Gulf Coast solitary bee at the following locations: Fort Morgan National Monument, Perdido Key State Park, Gulf Island National Seashore Perdido Key Unit, Topsail Hill State Park, Grayton Beach State Park, and St. Andrew's State Park. The beach mouse critical habitat is primarily located in fore dune regions of the beach with smaller amounts of habitat in the landward dunes, but the critical habitat enjoyed by the beach mice does not cover a significant amount of the observed range of the bee (Thetford et al. 2015 p. 59) nor do they offer specific or adequate protection from the specific threats of pesticide use, honey bee competition, inbreeding depression, or ensure adequate host plant resources or climate change mitigation.

Florida State park management plans address the Gulf Coast solitary bee in a limited way, however, any that do fail to provide adequate regulatory protections. Two parks describe natural history of the bee and outline limits on pesticide use (State of Florida 2013b p. 23,47, 2016a p. 23,56). However, overall awareness of this imperiled species is severely lacking at State parks and there are also no existing mechanisms to monitor, protect, or restore the populations of the Coastal Plain honeycomb head. As stated above, the Gulf Coast solitary bee requires foraging patches greater than 111.5m^2 no more than 475m from the shore; therefore, critical habitat must be designated in secondary or landward dunes that extend up to 475m from shore in order to protect the Gulf Coast solitary bee's habitat requirements of open, fine sandy nesting grounds and floral resources.

Existing regulations fail to set aside enough landward dunes habitat necessary for the bee's survival, especially considering the threats of habitat loss and fragmentation, resultant inbreeding, and climate change. Park management also lacks the consistent regulations necessary to prevent pesticide over spray or ensure sufficient host plant population levels that the Gulf Coast solitary bee requires. Additionally, the Coastal Barrier Resources Act and the Clean Water Act do not adequately prevent development of or pollution of the most critical habitat for the Gulf Coast solitary bee. The Gulf Coast solitary bee's preferred habitat, and where its honeycomb head host plant can be found, is in landward dunes with swales that house ephemeral wetlands (Hunsberger 2013 p. 21 and 65). Current proposed weakening of the Clean Water Act would directly impact the Gulf Coast solitary bee, as it would no

longer provide protection to ephemeral wetlands (University of New Hampshire 2019 p. 1). Listing on the ESA would protect critical habitat, restrict pesticide use, control disturbance, and raise awareness of this rare bee throughout its range, providing the only adequate regulatory mechanism for its protection.

Within National Park Service lands, the Gulf Coast solitary bee is not protected nor mentioned in the official management plan (National Park Service 2014). Thus, despite the fact that the Gulf Coast solitary bee has been diminished to have sole presence in protected areas, the bee is by no means sufficiently protected. While no species is able to survive long term in a few isolated populations, insects in particular have dynamic populations that vary annually and rely on specific and often ephemeral resources. Even if this rare bee's remaining populations are close enough for connectivity and the species is present in a metapopulation structure with natural colonization and extinction, its rare status means that extirpated populations (represented by unoccupied suitable habitat) are extremely important to the survival of the species, as they provide the only way for the species to expand and recover over time. These unoccupied areas are not in protected areas. In addition, because the Gulf Coast solitary bee has specific microhabitat requirements, they are generally only found in tiny pockets within the "protected areas" and most managers in these areas do not specifically manage for the bee's population health. Listing the Gulf Coast solitary bee is the only way to provide necessary protection within the parks but also give it the chance to survive and adapt as a species across its range.

To the extent that any voluntary, i.e. non-regulatory, mechanisms exist to protect the Gulf Coast solitary bee, FWS cannot rely on them to deny listing of species. Voluntary and unenforceable conservation efforts are *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)).

As demonstrated in this petition, the threats faced by the Gulf Coast solitary bee throughout its range are not adequately addressed by any of the bee's current designations. These threats to the bee's continued existence cannot be ameliorated via voluntary action. The only adequate regulatory mechanism available to save the Gulf Coast solitary bee starts with listing it under ESA.

Lack of Threat Amelioration

The Gulf Coast solitary bee is not currently protected from urbanization, habitat fragmentation, pesticides, honey bees, or climate change. There is no regulatory mechanism that ameliorates the negative effect of honey bees on native bees or the hybridization of African with European honey bees. Placement of apiaries is allowed on public land as a categorical exclusion under 36 CFR 220.6 and in some cases encouraged (Pollinator Health Task Force 2015 p. 44 and 48; Dickie 2015 p. 2) and with honey bee farmers looking to federal lands for pesticide free areas (Dickie 2015 p. 3), this is an imminent

threat not addressed by existing regulations. At minimum, any honey bee hives must be regulated to maintain a large (>10 km) distance from any Gulf Coast solitary bee for conservation effectiveness, ensuring no exploitative competition from managed honey bees (Henry & Rodet 2018 p. 3). However, as apiaries are a substantial threat to the whole ecosystem, hive placement on federal public lands must be substantially restricted (Geldmann & González-Varo 2018 pp. 1–2).

There are no protections for the Coastal Plain honeycomb head patches, many of which continued to be mowed and sprayed with herbicides, causing the bee to lose habitat. Two years ago the Parks Service mowed six different patches that were being monitored by scientists (Thetford & Miller 2019). Without the recognition of the Coastal Plain honeycomb head's importance to an endangered native pollinator, it will not be protected and, in turn, the Gulf Coast solitary bee will continue to lose habitat. Being in State Parks does not help protect the bee from pesticide spraying that is aerial or applied on roadsides because there is not an adequate buffer against roadside pesticide spraying on public roads (Thetford and Miller 2015 page. 12). Insecticides to control mosquitos are also used at Grayton Beach and St. Andrews Beach State Parks, despite their management plans having some language about protecting the Gulf Coast solitary bee (State of Florida 2013b p. 47, 2016a p. 47).

Lack of Connected Quality Habitat

The Gulf Coast solitary bee is lacking crucial connectivity between its isolated populations, breaking down its population dynamics. At the landscape, or range-wide, scale, the bee requires connectivity between patches. At the local, habitat level, the bee requires dense stands of host plants on undisturbed landward dunes with bare ground. As there is clear evidence that bees colonize patches with more host plants at the landscape scale, areas of high density honeycomb head pollen resources need to be created and maintained to buffer against extinction (Harper & Van Buren 2004 p. 490; Franzén & Nilsson 2009 p. 82, 2013 p. 1406).

Region-wide management is also needed to increase overall connectivity and reduce the negative effects of habitat fragmentation. Given the bee's small foraging range and distances between patches, effective management should assume that there is at least some inbreeding and diploid male production in the remaining populations. Stepping stone habitats or pockets of host plants on landward dunes within foraging distances of the Gulf Coast solitary bee are required to increase gene flow. Habitat protection and creation is especially required on coastal mainland sites to protect the bee from future sea level rise and severe storms. Translocating individuals between populations if connectivity cannot be achieved is also necessary (Zayed 2009 p. 242 and 244). The Service will need to protect occupied and potential habitat from urban development, degradation, and additional fragmentation across its range. These protections can only arise once the Gulf Coast solitary bee is listed under the ESA.

Request for Critical Habitat Designation

We urge the Service to designate critical habitat for the Gulf Coast solitary 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 Gulf Coast solitary bee's chance for survival significantly diminishes. The petitioner thus requests that the Service propose critical habitat for the bee concurrently with its listing.

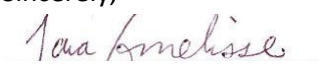
Conclusion

In this petition, we have carefully assessed the best scientific and commercial information available regarding the Gulf Coast solitary bee, inlcuding the historic, present, and future threats faced by the Gulf Coast solitary bee and have determined that the species is in imminent danger of extinction throughout its range. The ESA requires that the Service 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).

There is no question that protecting the Gulf Coast solitary bee is warranted under the Act as it is imperiled by 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 affecting its continued existence. There are no existing regulatory mechanisms which are adequate to protect the Gulf Coast solitary bee. The Service must act promptly to protect this species and to designate critical habitat in order to prevent its extinction and reverse its precipitous decline in range and habitat. Listing of the Gulf Coast solitary bee as an endangered species provides continued existence for a species that would otherwise be a guaranteed victim of the synergistic threats of urbanization, climate change, and pesticides. Conserving this bee would in turn conserve the unique dune ecosystems of the northern Gulf Coast of the United States.

Please contact me at 503-283-5474 and/or tcornelisse@biologicaldiversity.org if you have any questions or need any clarification on the above information.

Sincerely,



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