The Buzz on Bees in Michigan

Logan Rowe & David Cuthrell
Michigan State University
Michigan Natural Features Inventory

Michigan Natural Features Inventory

MICHIGAN STATE UNIVERSITY

Outline

- Background to Bumbles and Other Bees
- Threats to Bumbles and Other Bees
- Bumble Bee Declines
- Bumble Bees of Michigan
- Setting Long Term Goals
- How to Get Involved

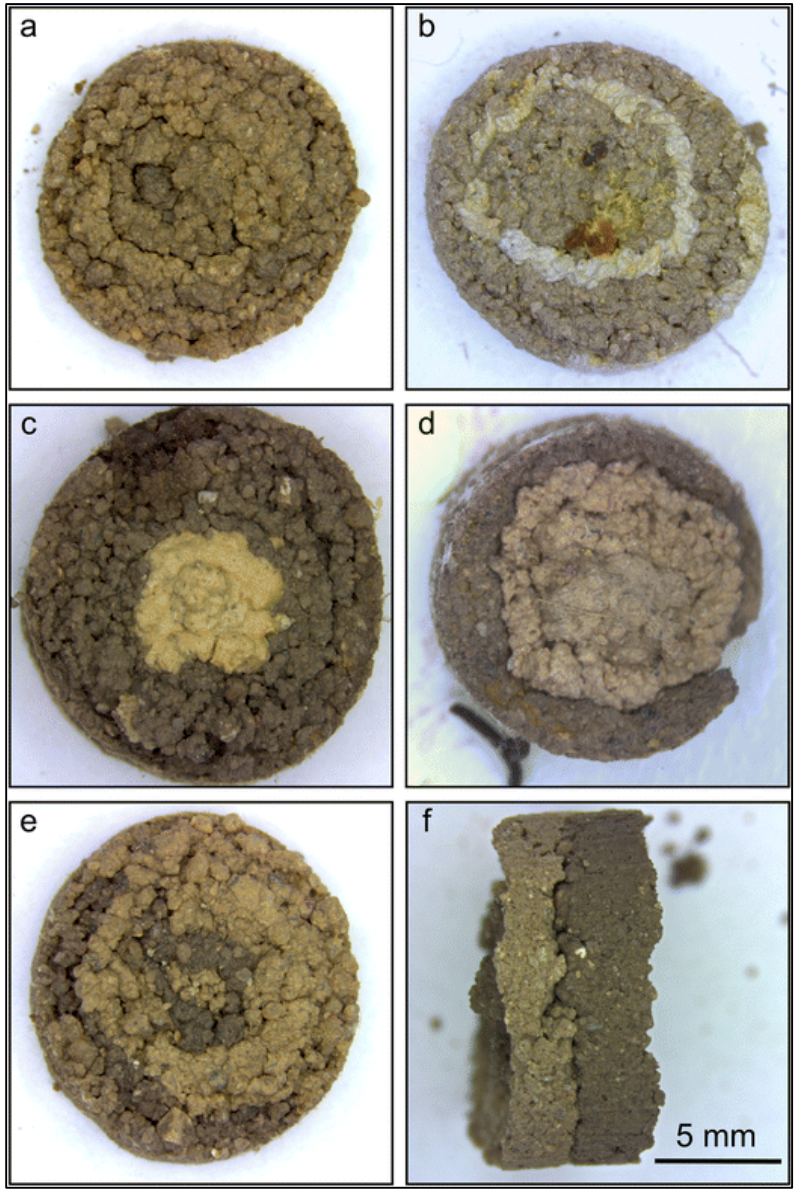
Diversity

Over 465 Species

Photos: Sam Droege

Diversity- Mason Bees

- Solitary stem nesters
- Construct nests with mud/clay
- Bee hotels



Pinilli-Gallego and Isaacs, 2018

Diversity

Over 465 Species

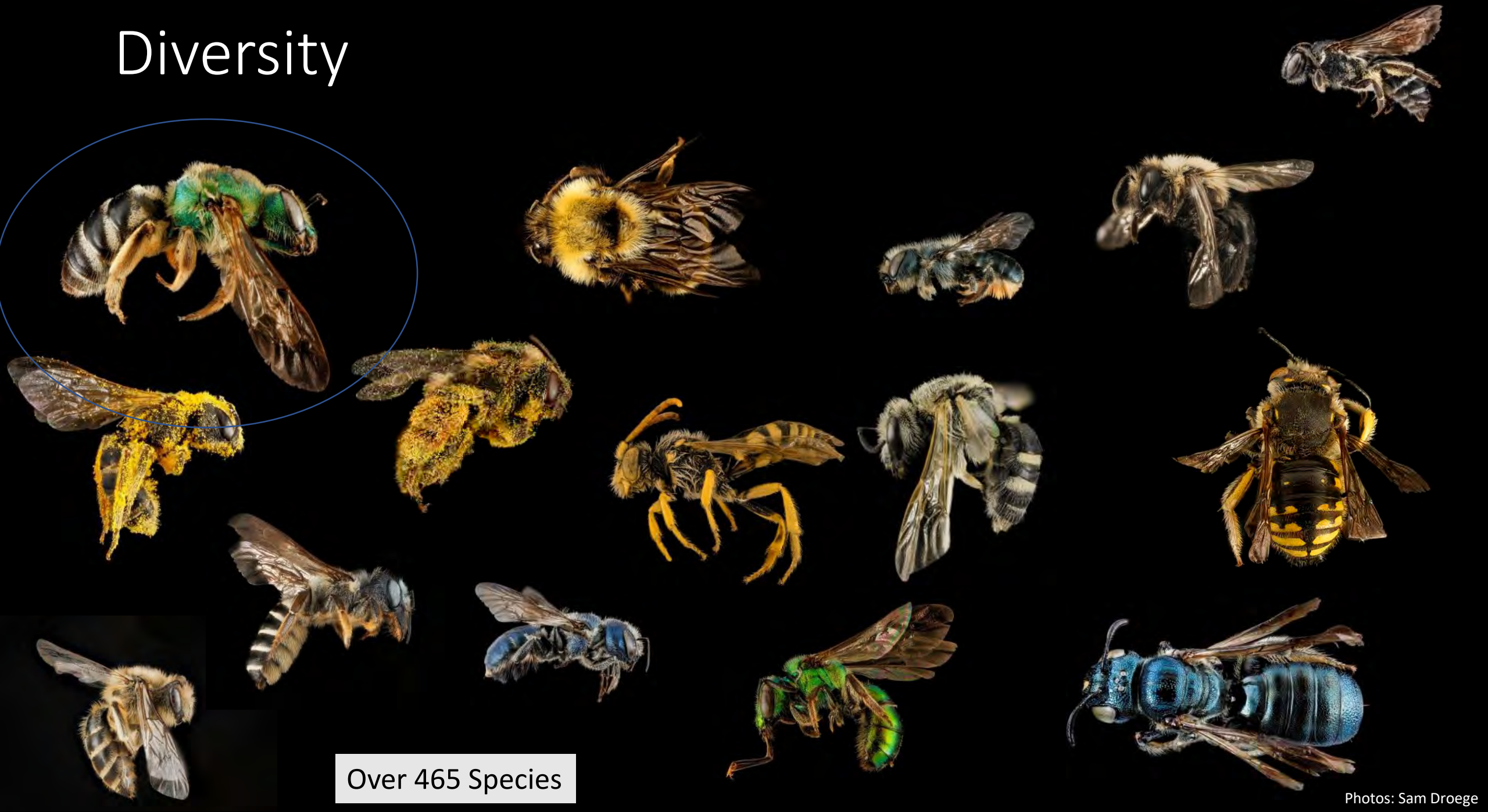
Photos: Sam Droege

Diversity- Leaf Cutter Bees

- Solitary stem nesters
- Construct nests with plant material
- Bee hotels

Photos from: Jason Gibbs

Diversity



Over 465 Species

Photos: Sam Droege

Diversity- Sweat Bees

- Ground or wood nesters
- Socially diverse
- 120+ species

Diversity

Over 465 Species

Photos: Sam Droege

Diversity- Cuckoo Bees

- Kleptoparasitic
- Do not collect pollen
- Wasp-like in appearance

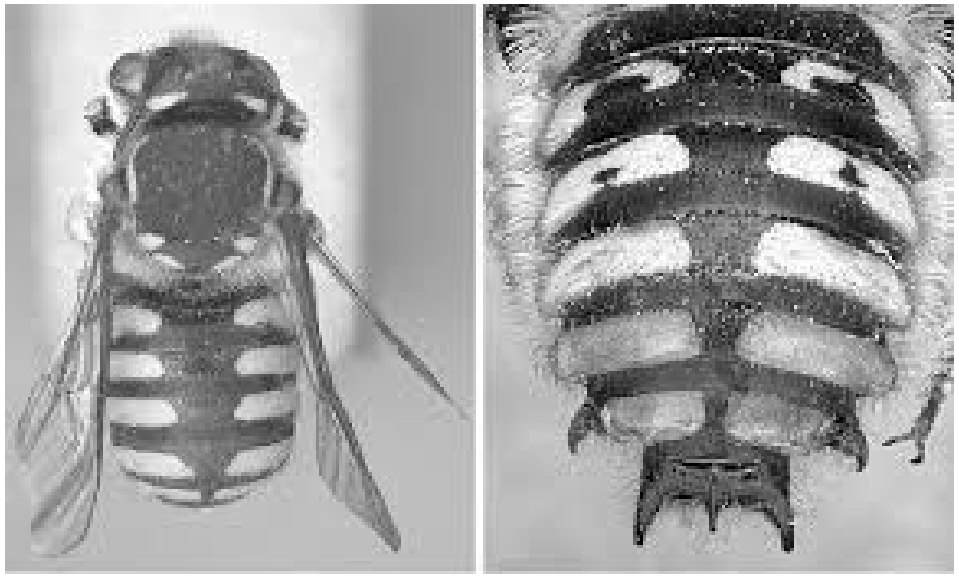
Diversity

Over 465 Species

Photos: Sam Droege

Diversity- Wool Carder Bees

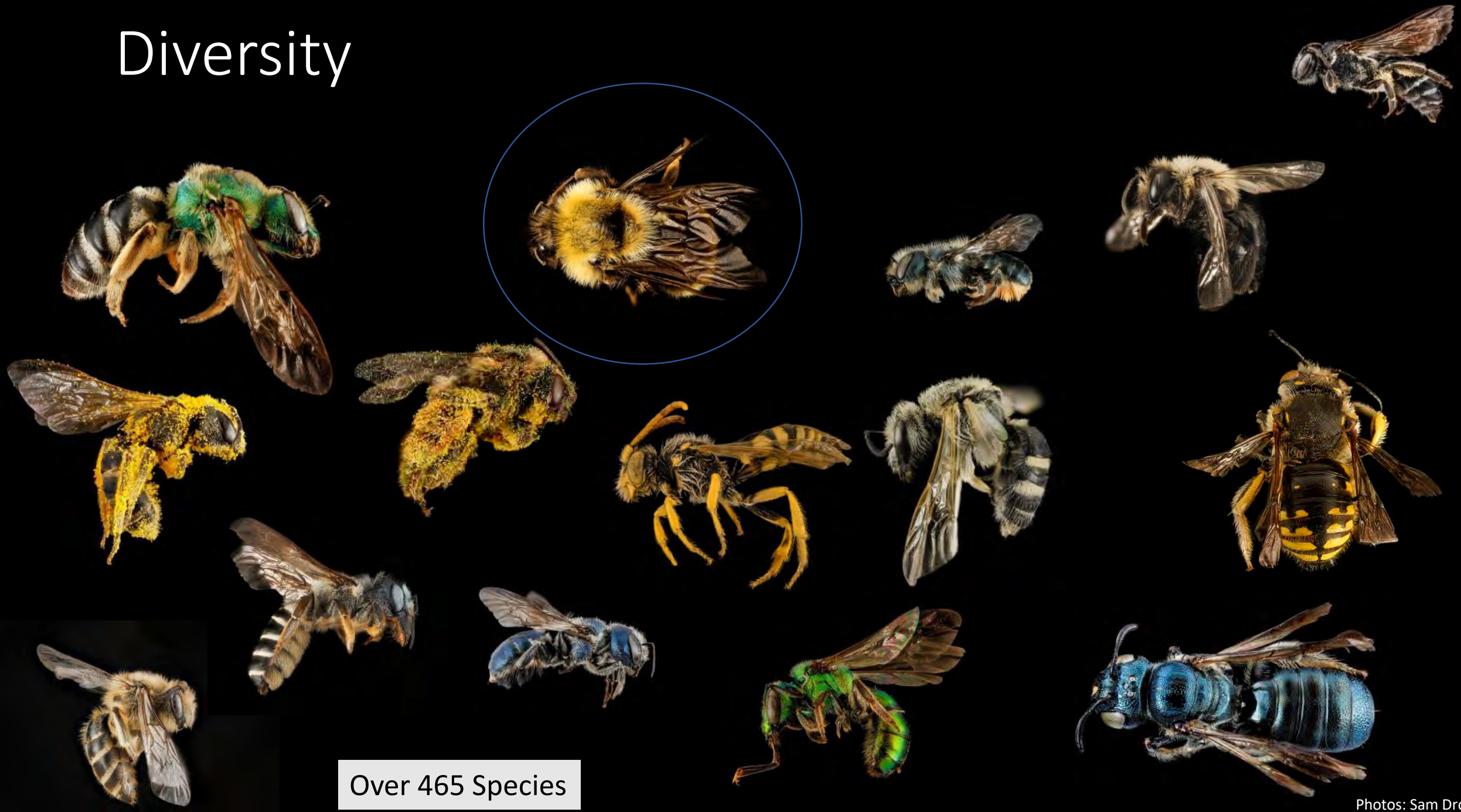
- Males territorial and aggressive
- Stem nesters
- Invasive: *Anthidium manicatum*



Strange et al. 2011

Gibbs and Sheffield, 2008

Diversity



Over 465 Species

Photos: Sam Droege

Diversity- Bumble Bees

- Social – Kleptoparasitic
- Most well understood
- Buzz pollination
- 20(?) species in Michigan

Life Cycle of Bumble Bees

Threats- The BIG Three

1. Habitat Loss

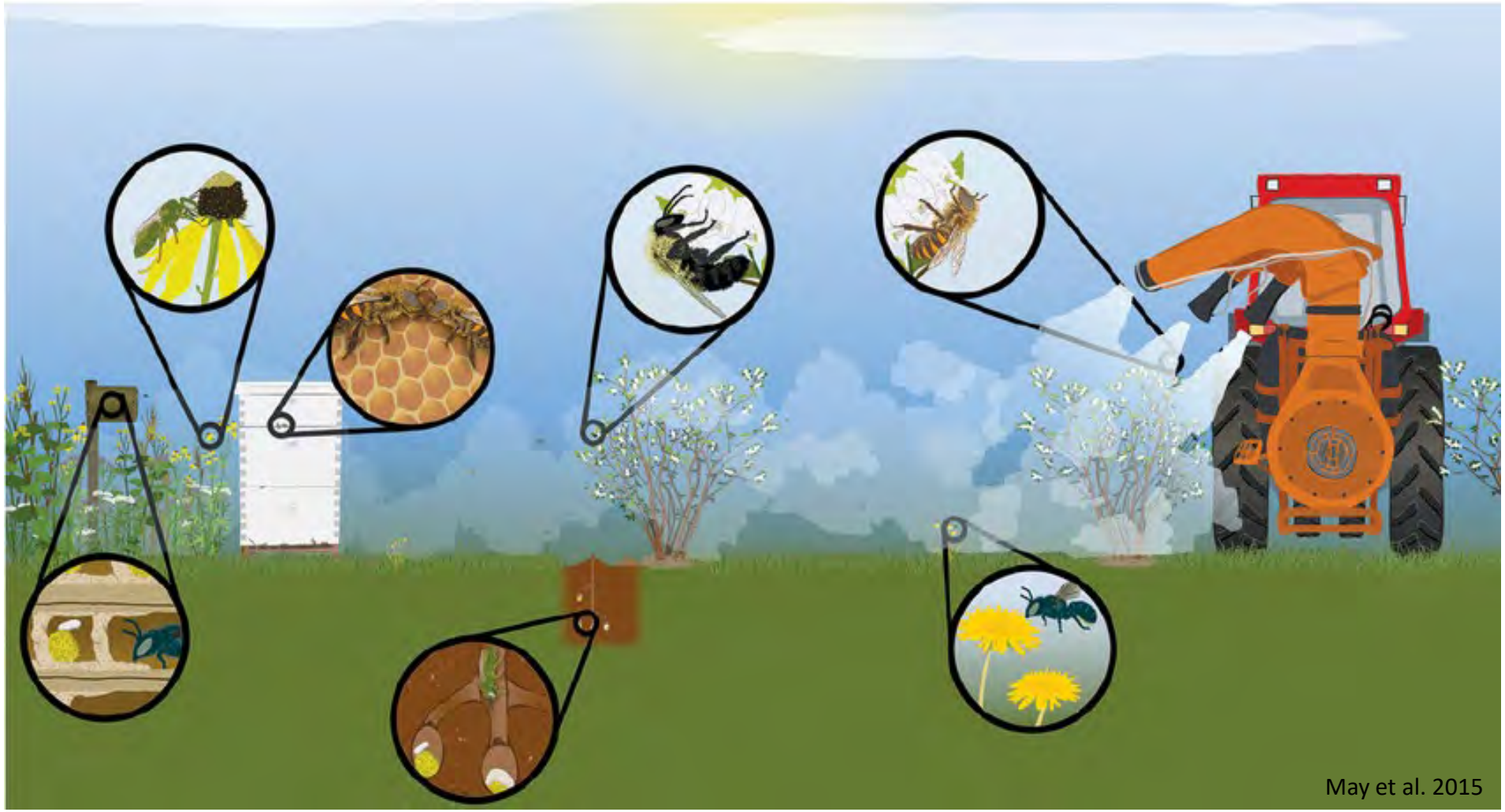
High Complexity

Low Complexity

Landis 2017

Threats- The BIG Three

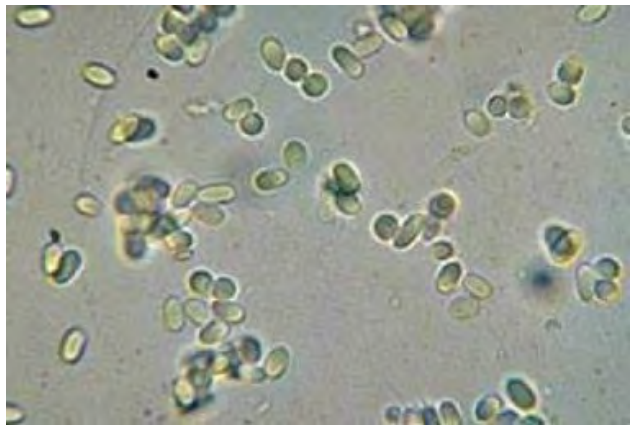
2. Pesticides



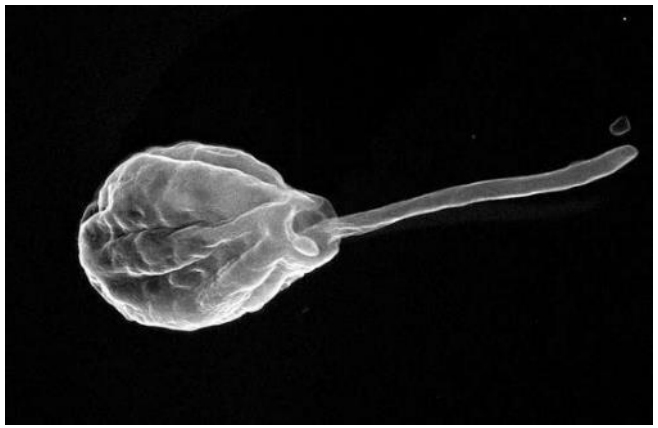
May et al. 2015

Threats- The BIG Three

3. Parasites/Pathogens

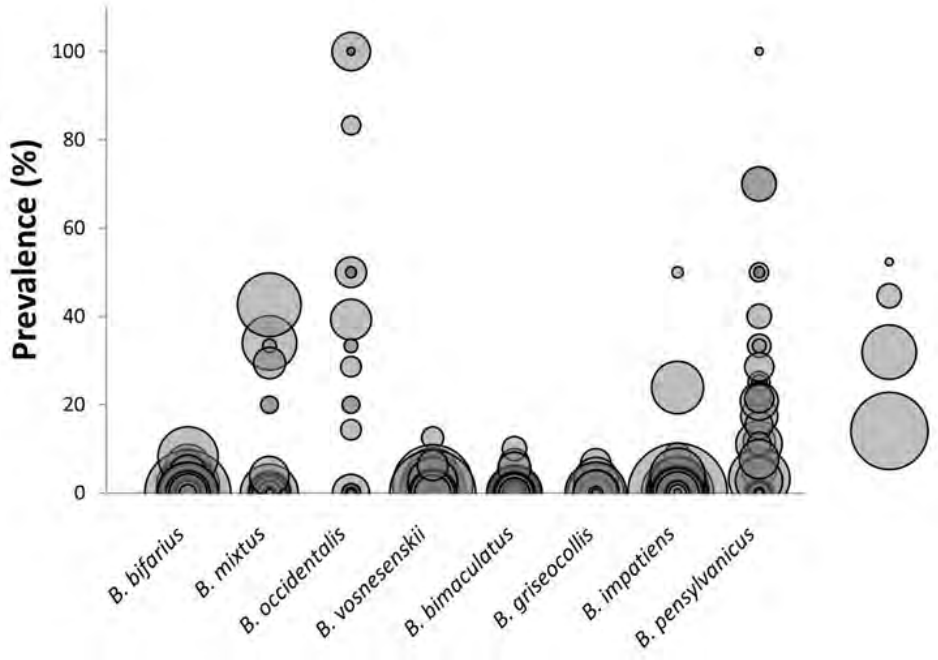


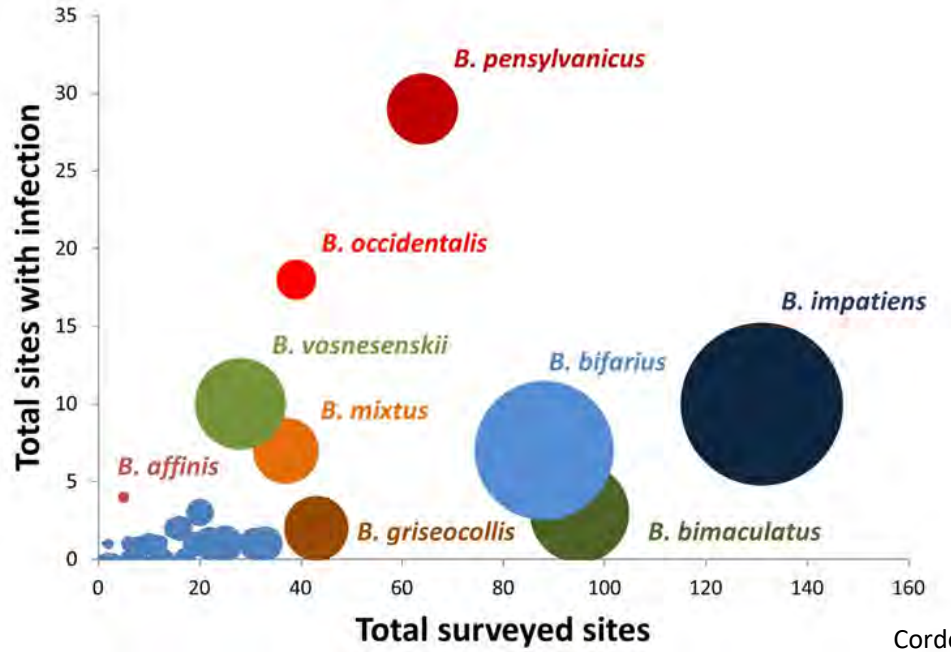
Nosema bombi



Crithidia bombi

mites

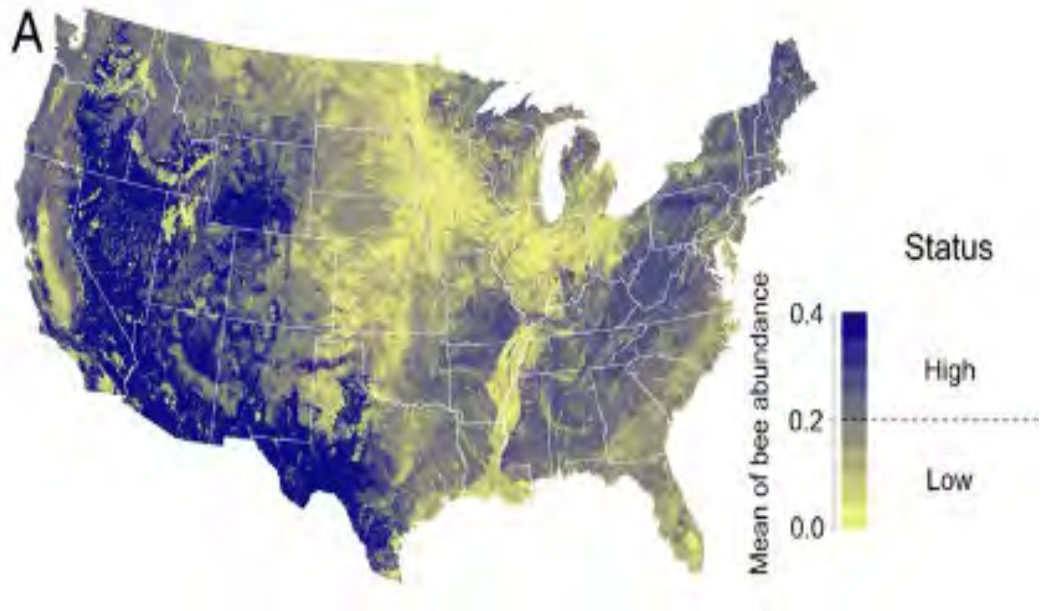




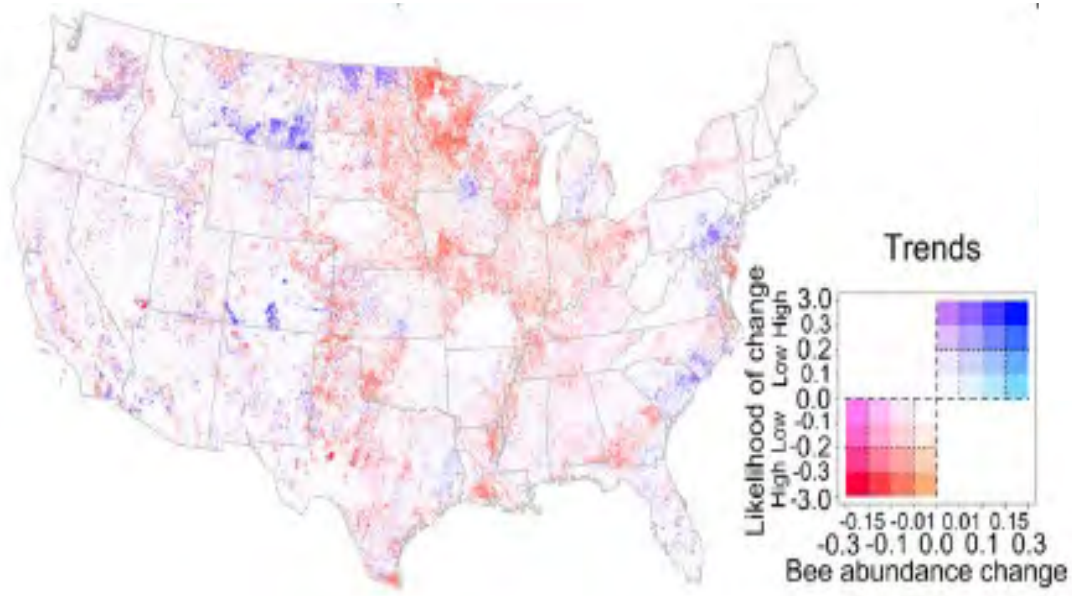
Cordes 2009

Land-use change

Cause for Concern?



Mean of Bee Abundance (2013)

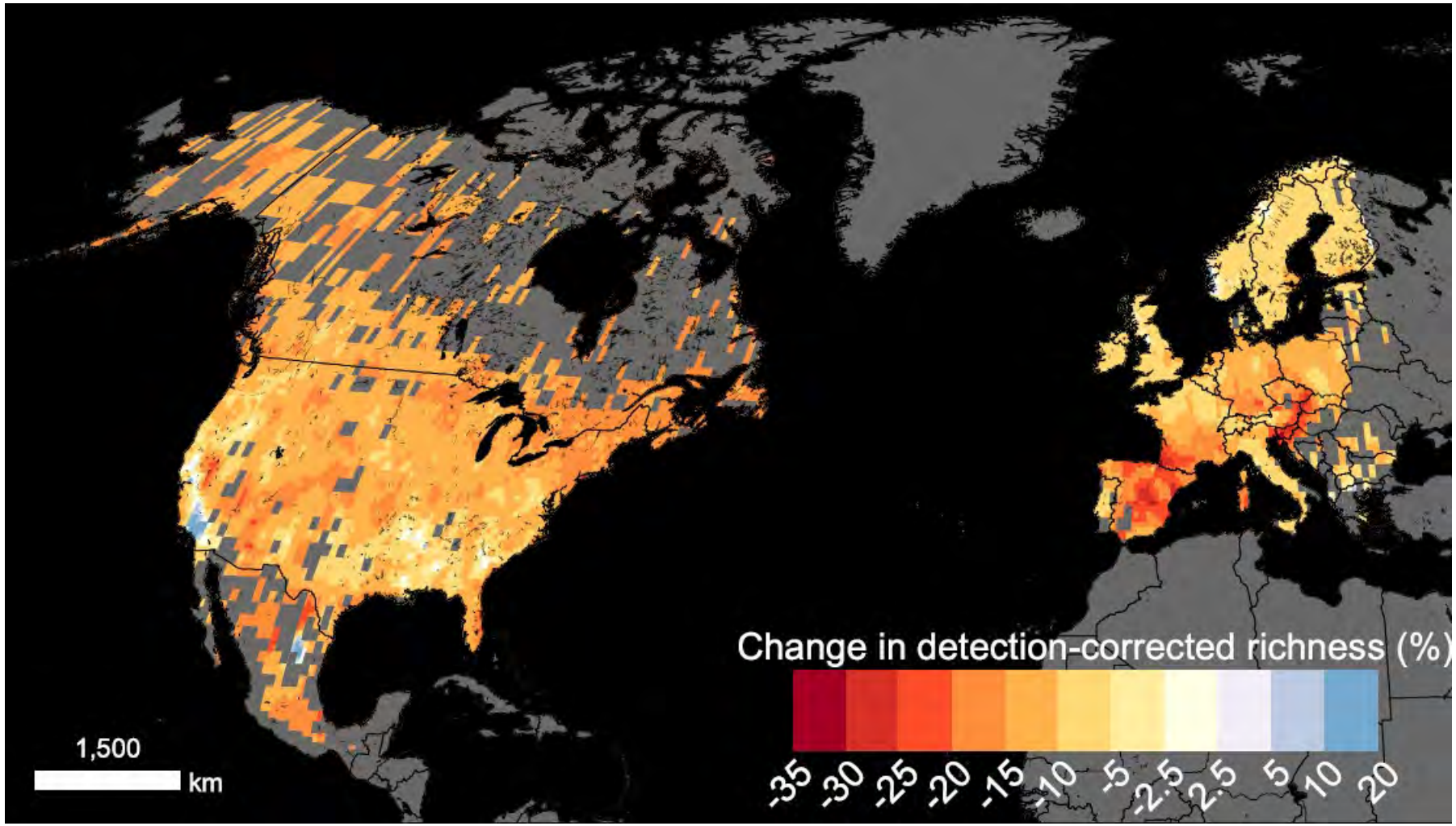


Likelihood of Change in Abundance (2008-2013)

Between 2008 and 2013, modeled bee abundance declined across 23% of US land area.

Koh et al. 2015

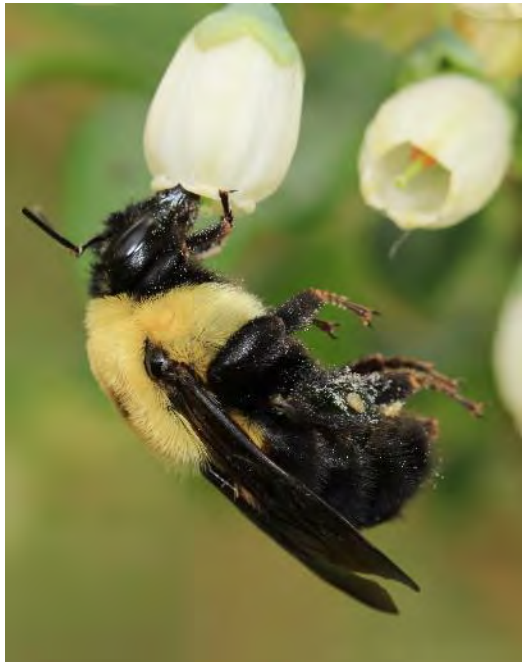
Cause for Concern?



Climate change related change in bumble bee species richness from a baseline (1901–1974) to a recent period (2000–2014) in relation to shifting temperature and precipitation patterns.

Soroye et al. 2020

Value- Pollination Services



- 87.5% of flowering plants rely on insect pollinators
  - Including 75% of of the leading food crops
- Pollination services are worth nearly $351 billion annual and contribute to 9.5% of the total economic value of world agricultural output
  - Much more if natural areas are also considered

Klein et al. 2007, Gallai et al. 2008, Ollerton et al. 2011, Lautenbach et al. 2012

Value- Conservation Education & Outreach

Community Engagement

Grower Outreach

Citizen Science

Value- Conservation Education & Outreach

Charismatic creature

Value- Building Collaborations

Bombuss 2.0 in Toronto

Bumble Bees of Michigan

B. affinis

B. auricomus

B. pensylvanicus

B. fervidus

B. ternarius

B. terricola

B. fernaldae

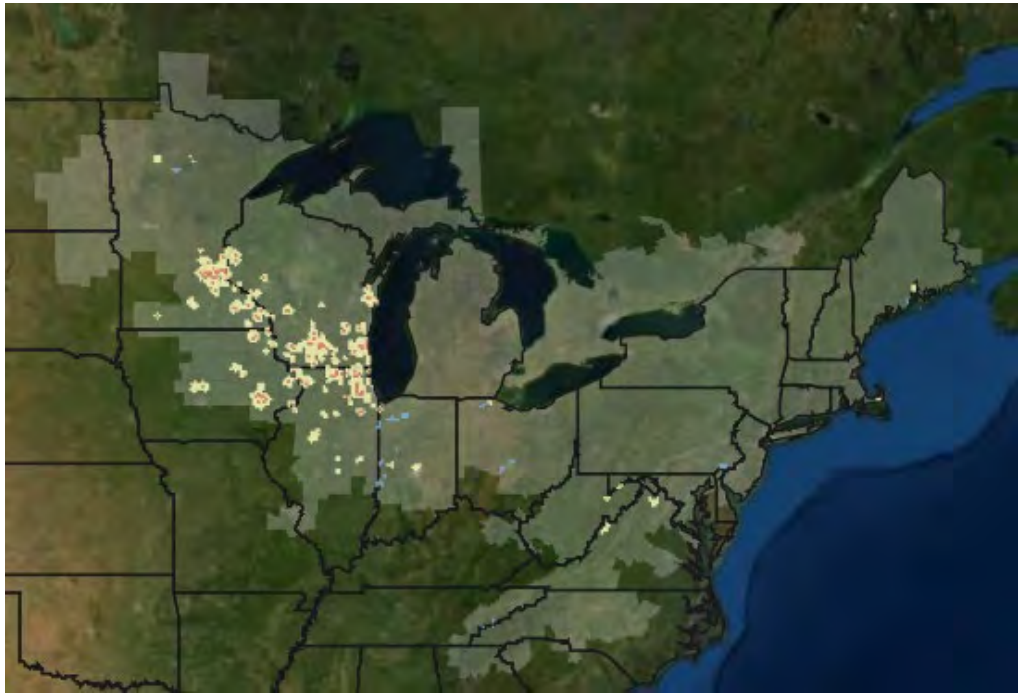
B. rufocinctus

Historically 20 species in total

Bumble Bees of Michigan

Species	Common Name
Bombus affinis	Rusty-patched bumble bee
Bombus auricomus	Black-and-gold Bumble Bee
Bombus bimaculatus	Two-spotted Bumble Bee
Bombus ashtoni	Gypsy Cuckoo Bumble Bee
Bombus borealis	Northern Amber Bumble Bee
Bombus citrinus	Lemon Cuckoo Bumble Bee
Bombus fervidus	Yellow bumble bee
Bombus fernaldae	Fernald's Cuckoo Bumble Bee
Bombus fraternus	Southern Plains Bumble Bee
Bombus frigidus	Frigid Bumble Bee
Bombus griseocollis	Brown-belted Bumble Bee
Bombus impatiens	Common Eastern Bumble Bee
Bombus insularis	Indiscriminate Cuckoo Bumble Bee
Bombus pensylvanicus	American bumble bee
Bombus perplexus	Confusing Bumble Bee
Bombus rufocinctus	Red-belted Bumble Bee
Bombus sandersoni	Sanderson's Bumble Bee
Bombus ternarius	Tri-colored Bumble Bee
Bombus terricola	Yellow banded bumble bee
Bombus vagans	Half-black Bumble Bee

- 2015- Michigan Wildlife Action Plan lists *B. affinis* and *B. terricola* as Species of Greatest Conservation Need.
- 2016- *B. terricola* was listed on the USFW Service 7-year workplan
- 2017- *B. affinis* officially listed as Federally Endangered.



B. affinis historic and current range, source: USFW

Early Documentation of Occurrence

DESCRIPTION AND BIOLOGY OF BUMBLEBEES (HYMENOPTERA: APIDAE) IN MICHIGAN

Robert W. Husband,[1] Roland L. Fischer[2] and T. Wayne Porter[3]

The distribution of Michigan Bombinae was first studied by Milliron (1939). Records of Michigan bumblebees were included in Cockerell (1916) Franklin (1912), Lutz and Cockerell (1920), and Mitchell (1962). Other major studies in the Great Lakes Region were Chandler (1950) for Indiana, Medler and Carney (1963) for Wisconsin, Husband (1966) for Michigan, Macfarlane (1974) for Ontario, LaBerge and Webb (1962) for Nebraska, Stevens (1948) for North Dakota, Frison (1926) for Illinois, and Neave (1933) for Manitoba. The purpose of this paper is to add to the information presented by Milliron (1939) and to complement the works by Chandler, Medler and Carney, and Macfarlane. Generic nomenclature follows Hurd in Krombein et al. (1979).

LIFE CYCLE

A generalized life cycle for Michigan bumblebees is summarized in Figure 1. Variations in the basic pattern are related to differences in species, differences in latitude, and individual differences among bees. Holm (1960), for example, observed *Bombus terrestris* queens in Denmark emerging as early as 2 April and as late as 2 June. Under greenhouse conditions, 91% of queen *B. terrestris* had emerged by 3 May. The generalizations in Figure 1 are based on the pattern for *Bombus vagans* at 42°N latitude (southern Michigan).

When the temperature becomes warmer in the spring, queens emerge from hibernation. Hibernation sites are often in soil, 2.5–20.0 cm below the surface. They may also be found under logs or among the multiple, leaf-covered stems of shrubs. Survival rates of overwintering queens vary with environmental factors, physiological factors (fat body storage), and other factors, but may be as high as 84% (Holm 1960). As queens feed on cherry blossoms and other early blooming plants, their ovaries enlarge and mature. A period of nest-seeking begins, and queens may be observed flying close to the ground in a seemingly random fashion.

A number of queens die without initiating nests. Deaths may be related to a small fat body or disease (Skou et al. 1963), to the fatal combats which queens have in competition for nest sites (Frison 1928, Plath 1934, Hobbs 1967), or to other factors such as predation or accidental death. Porter and Husband found numerous dead queens washed up on the shore of Lake Superior. Nest sites in lower Michigan are frequently former rodent nests. Three such rodent species identified by skeletal remains, grass clippings, food remains, construction materials, or other nest characteristics were: *Peromyscus leucopus* (Rafinesque), *Microtus pennsylvanicus* (Ord) and *Spermophilus tridecemlineatus* (Mitchill). Some species of bumblebees construct their own nests in insulation, dry grass, or other materials.

After queens enter an abandoned rodent nest or other potential nest site, they rearrange the nest materials to form a brood chamber. Wax, which is exuded between abdominal segments, accumulates on the floor of the small cavity at the center of the nest. This is formed into a wax thimble-sized structure known as a honey pot. Egg cells may be formed

Husband et al. 1980

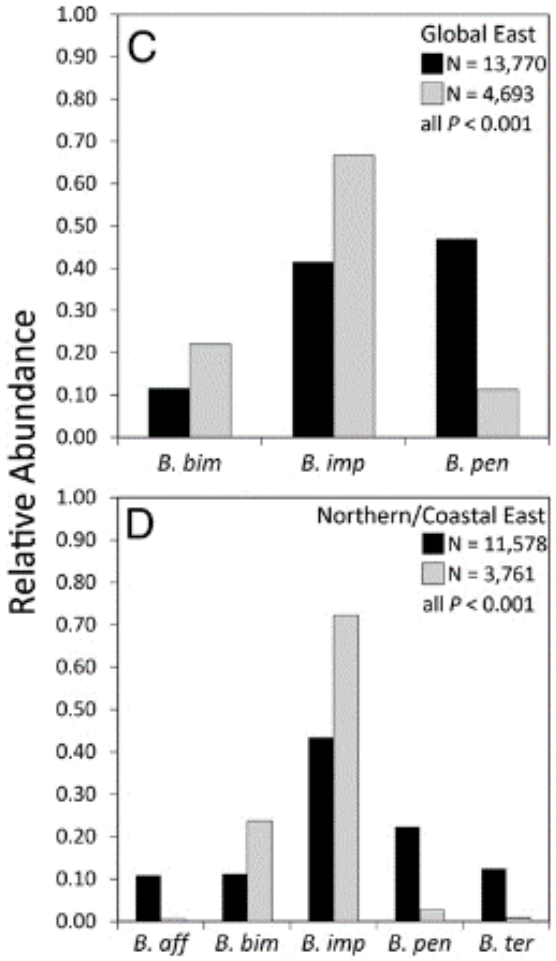
- Milliron 1939
- Husband et al. 1980
- Focused on species **Documentation**

Table 1. The dates of the earliest records of appearance of bumblebees in Michigan.

Species	Queens	Workers	Males
Bombus (Bombias) nevadensis	5 May	30 June	10 Aug.
Bombus (Bombus) affinis	14 Apr.	27 June	25 July
Bombus (Bombus) terricola	14 Apr.	10 June	6 July
Bombus (Cullumanobombus) rufocinctus	24 May	3 July	11 Aug.
Bombus (Fervidobombus) fervidus	6 May	1 June	16 Aug.
Bombus (Fervidobombus) pennsylvanicus	30 May	28 June	26 Aug.
Bombus (Pyrobombus) bimaculatus	15 Apr.	16 June	4 July
Bombus (Pyrobombus) impatiens	14 Apr.	17 June	5 Aug.
Bombus (Pyrobombus) perplexus	12 Apr.	2 June	5 July
Bombus (Pyrobombus) ternarius	3 May	10 June	22 Aug.
Bombus (Pyrobombus) vagans	17 Apr.	19 June	2 July
Bombus (Separatobombus) griseocollis	5 May	10 June	10 July
Bombus (Subterraneobombus) borealis	13 May	30 June	11 July
Psithyrus ashtoni	21 May	—[a]	23 July
P. citrinus	2 July	—[a]	28 July
P. fernaldae	29 May	—[a]	21 July
P. insularis	31 May	—[a]	6 Aug.

[a]No workers in this species.

Documentation of Declines



Cameron et al. 2010

Table 3 Assessment of declining eastern North American bumble bee species using modified IUCN red list criteria

Species	Rank	Rationale
B. affinis	EN	RD > 70 %
*B. ashtoni**	VU	RD > 50 %
B. auricomus	VU	RD > 50 %
B. borealis	EN	RD > 70 %
*B. fernaldae**	EN	RD > 70 %
B. fervidus	EN	ID > 70 %
B. fraternus	EN	RD > 70 %
*B. insularis**	VU	RD > 50 %
B. pensylvanicus	VU	RD > 50 %
B. sandersoni	EN	RD > 70 %
*B. variabilis**	CR	RD > 90 %

The rationale "RD" (range decline) provides the decline in occupancy in re-sampled historical range between 1960–90 and 1991–2009 time periods, "ID" (index decline) provides the decline in index of relative abundance over all time periods

CR critically endangered, *EN* endangered, *VU* vulnerable

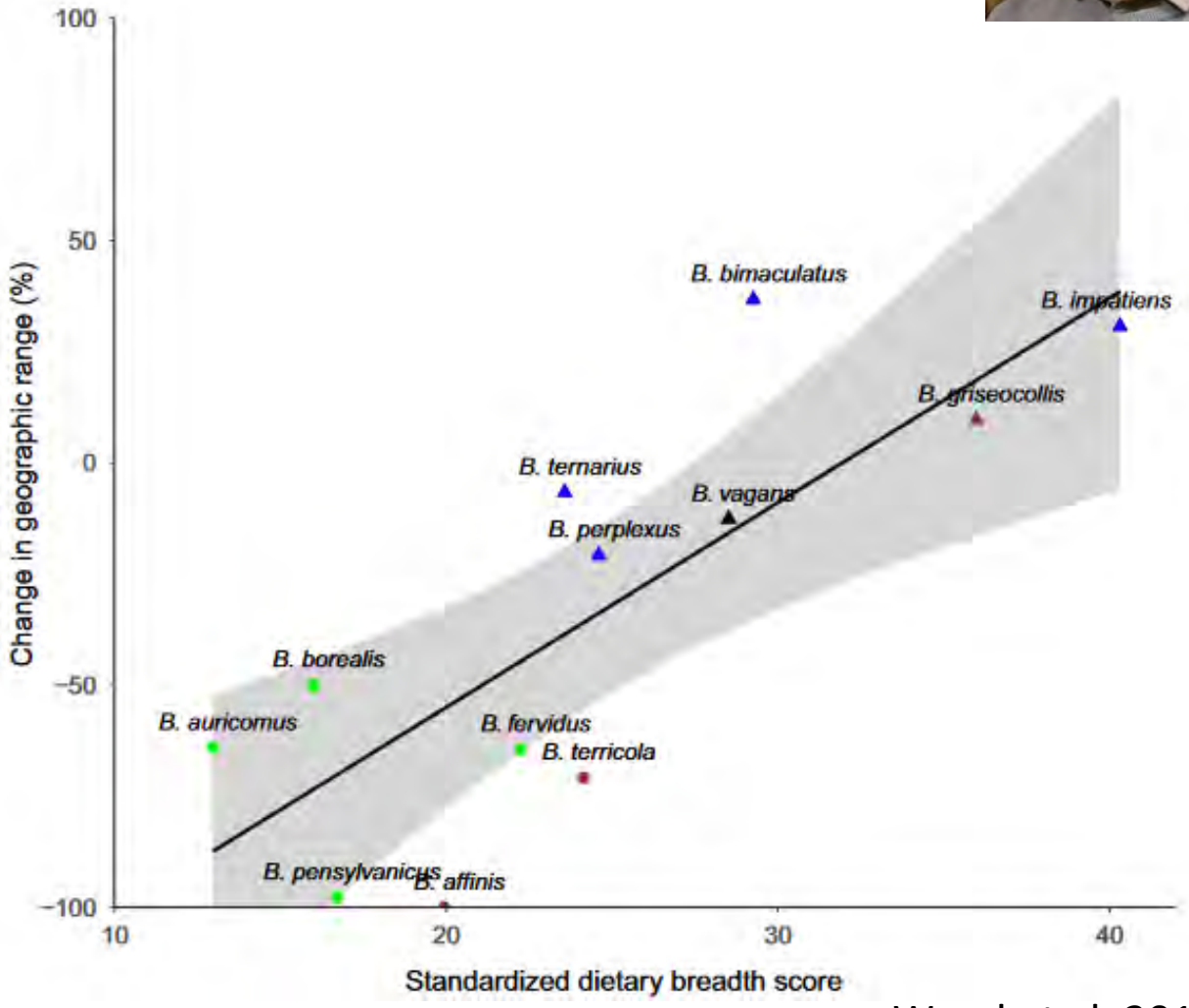
* Denotes cuckoo species

Colla et al. 2012

Bumble Bee Declines in Michigan

TABLE 2. Changes in range for selected Michigan bumble bee species between the pre- and post-2000 period.

Species	Tongue length	No. occupied counties		% decline
		Pre-2000	Post-2000	
Bombus affinis	Short	49	0	−100.0
Bombus auricomus	Long	39	14	−64.1
Bombus bimaculatus	Medium	49	67	+36.7
Bombus borealis	Long	54	27	−50.0
Bombus fervidus	Long	76	27	−64.5
Bombus griseocollis	Short	72	79	+9.7
Bombus impatiens	Medium	62	81	+30.6
Bombus pensylvanicus	Long	45	1	−97.8
Bombus perplexus	Medium	53	42	−20.8
Bombus ternarius	Medium	45	42	−6.7
Bombus terricola	Short	72	21	−70.8
Bombus vagans	Medium–long	79	69	−12.7



Wood et al. 2019

Bumble Bee Declines in Michigan

Assessing Bumble Bee Diversity, Distribution, and Status for the Michigan Wildlife Action Plan

Prepared By:
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Lansing, MI 48901

Prepared For:
Michigan Department of Natural Resources
Wildlife Division

12/17/2019

MNFI Report No. 2019-33

Michigan Natural Features Inventory MICHIGAN STATE UNIVERSITY Extension

Objectives:

1) Develop dataset of all bumble bee occurrences in Michigan
2) Determine historic and current ranges based on abiotic/environmental conditions
3) Conduct conservation status assessments (s-ranks) for each bumble bee species
4) Construct habitat suitability model for *B. terricola*

Bumble Bee Declines in Michigan

- Museum searches (MSU, UofM)
- Academic collections (Rufus Isaacs Lab)
- Citizen science (iNaturalist, BumbleBee Watch)
- Personal collections (various)
- Statewide surveys (2016-2018)

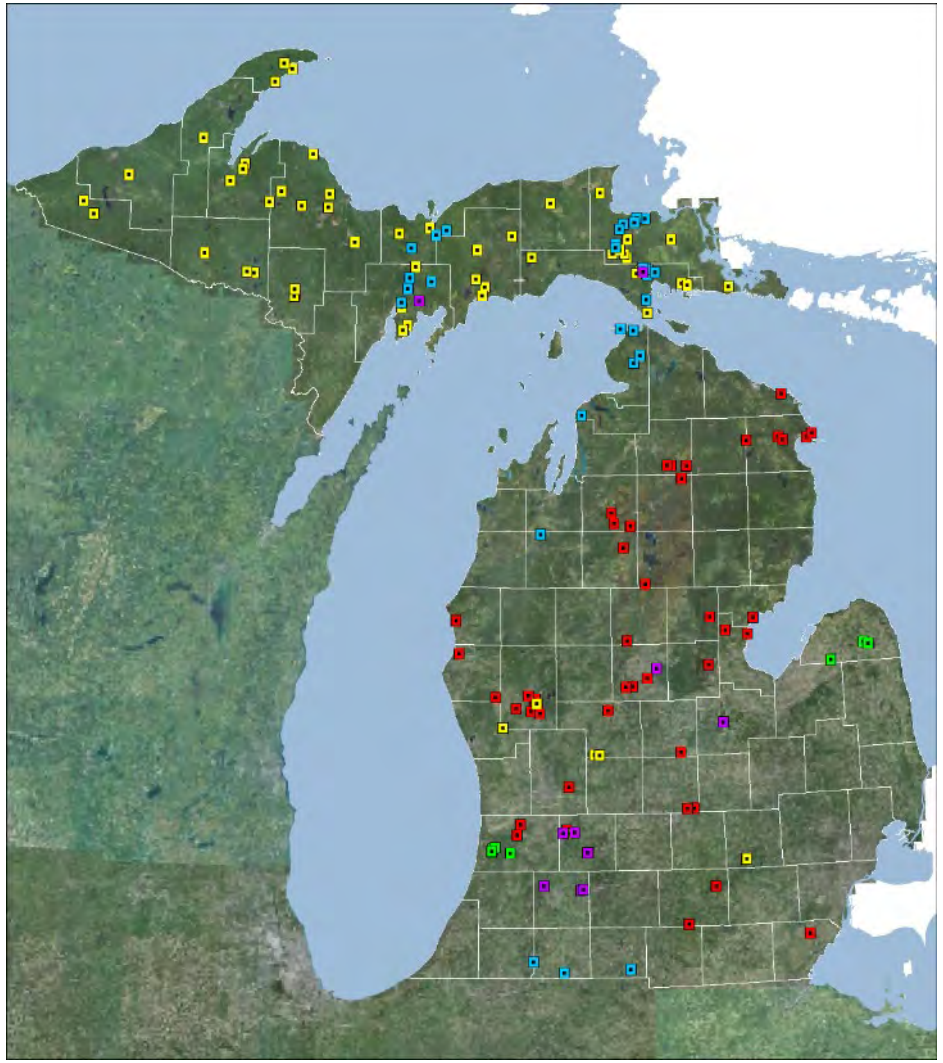
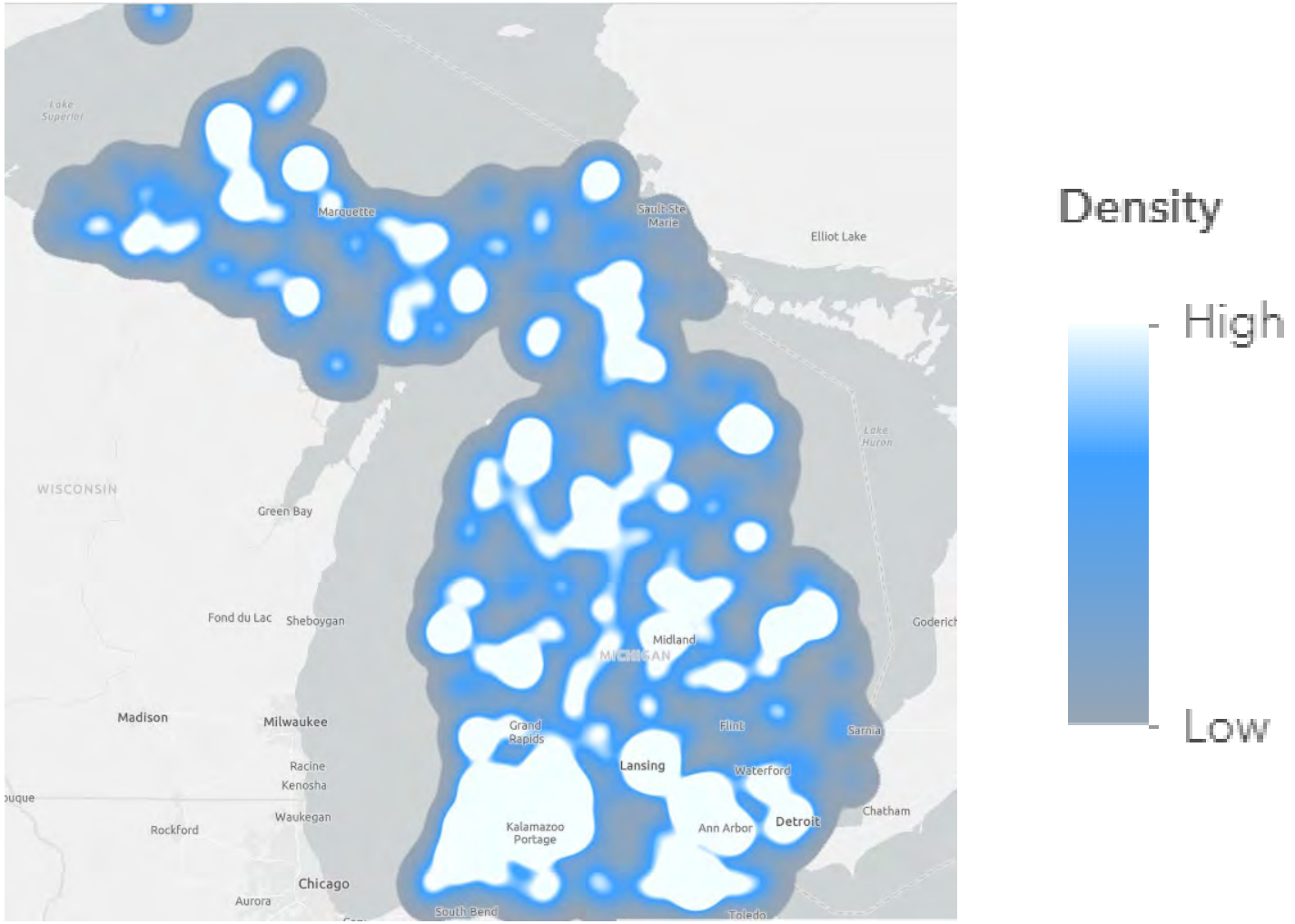


Figure 2. Locations of MNFI bumble bee surveys during 2016 (red), 2017 (yellow), 2018 (blue). Additional sites sampled as part of the cSWG grant: Pollinator Conservation thorough enhancement of Michigan's and Wisconsin's Grassland, Prairie, and Savanna Habitat (green), and incidental surveys (purple) are also shown.

Sampling Efforts in Michigan

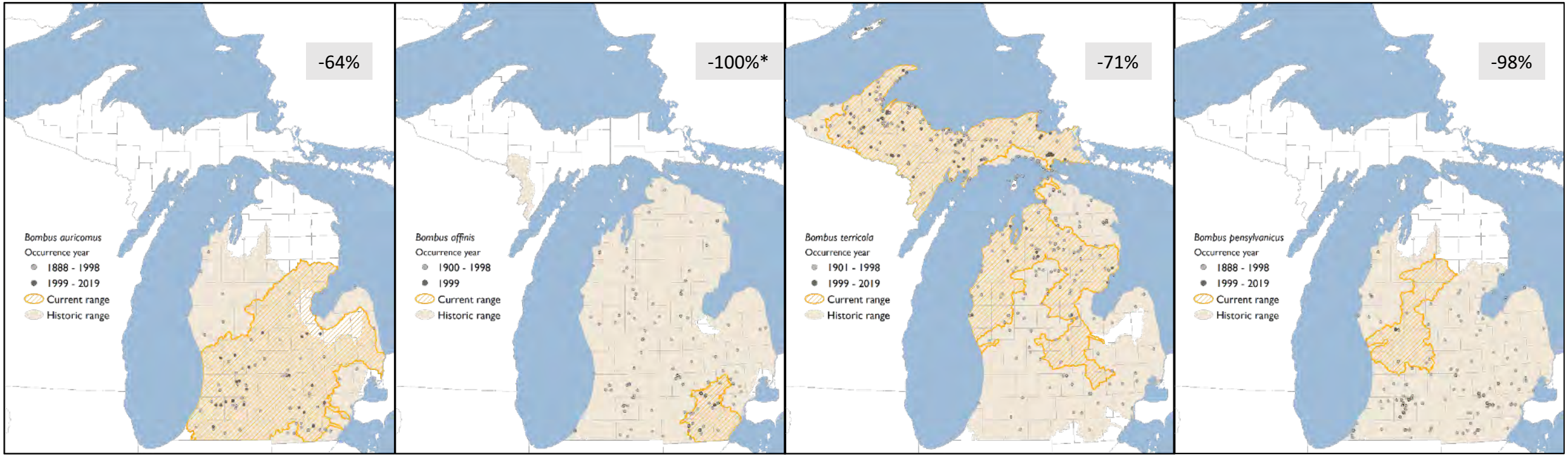


Density of bumble bee observations in Michigan from late 1800s through 2019

Map by Courtney Ross

Bumble Bee Declines in Michigan

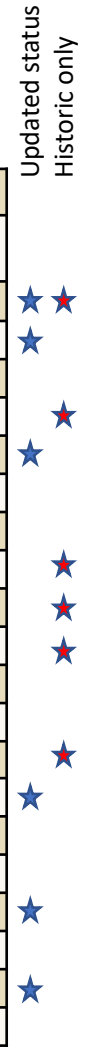
- All *Bombus* split into two temporal groups: current (1999-2019) and historic (pre-1999)
- Distributions determined using 8-digit Hydrological Unit Code (HUC) watershed polygons



Bumble Bee Declines in Michigan

- Used NatureServe's standardized Element Rank Calculator
- Informed by species rarity, trends, threats, expert opinion (scored 1-5)
- Used widely for most of Michigan's SGCN S-ranks

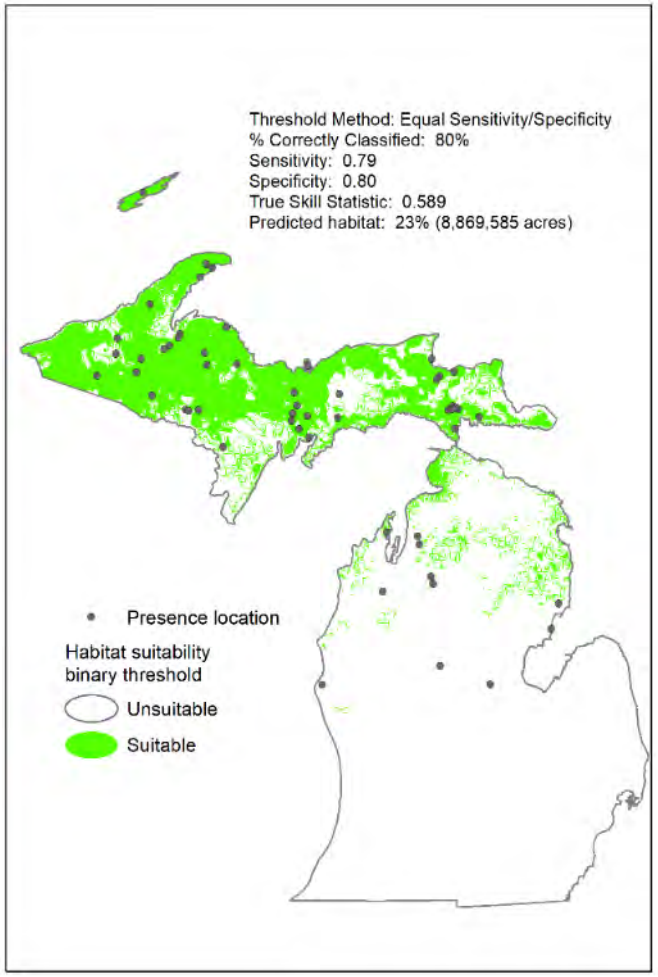
Species	Common Name	Global Rank	State Rank				State Status - MI
			Michigan	Wisconsin	New York	Indiana	
Bombus affinis	Rusty-patched bumble bee	G2	**SH**	S1	SH	S1	proposed Endangered
Bombus auricomus	Black-and-gold Bumble Bee	G4G5	**S2**	S3	S1	S3	Special Concern (SC)
Bombus bimaculatus	Two-spotted Bumble Bee	G5	**S4**	S4	S5	S5	
Bombus ashtoni	Gypsy Cuckoo Bumble Bee	G3G5	**SH**	S1?	SH	S1	
Bombus borealis	Northern Amber Bumble Bee	G4G5	**S3**	S3	S1	SH	proposed SC
Bombus citrinus	Lemon Cuckoo Bumble Bee	G4	**S3**	S3	S5	S4	
Bombus fervidus	Yellow bumble bee	G3G4	**S3**	S2	S1	S3	
Bombus fernaldae	Fernald's Cuckoo Bumble Bee	G5?	**SH**	SNR	SH	SNR	
Bombus fraternus	Southern Plains Bumble Bee	G2G4	**SH?**	--	--	S3	
Bombus frigidus	Frigid Bumble Bee	G5	**SH?**	S1	--	--	
Bombus griseocollis	Brown-belted Bumble Bee	G5	**S5**	S4	S5	S5	
Bombus impatiens	Common Eastern Bumble Bee	G5	**S5**	S5	S5	S5	
Bombus insularis	Indiscriminate Cuckoo Bumble Bee	G3	**SH**	S1S2	SH	SX	
Bombus pensylvanicus	American bumble bee	G3G4	**S1**	S1	S1	S3	proposed Threatened
Bombus perplexus	Confusing Bumble Bee	G5	**S3S4**	S1	S4	S3	
Bombus rufocinctus	Red-belted Bumble Bee	G4G5	**S3S4**	S4	S3S4	SNR	
Bombus sandersoni	Sanderson's Bumble Bee	G4G5	**S2S3**	S1S3	S3S4	--	proposed SC
Bombus ternarius	Tri-colored Bumble Bee	G5	**S4**	S4	S3S4	SH	
Bombus terricola	Yellow banded bumble bee	G3G4	**S2S3**	S1	S1	SH	SC
Bombus vagans	Half-black Bumble Bee	G4	**S4**	S4	S4	S3	



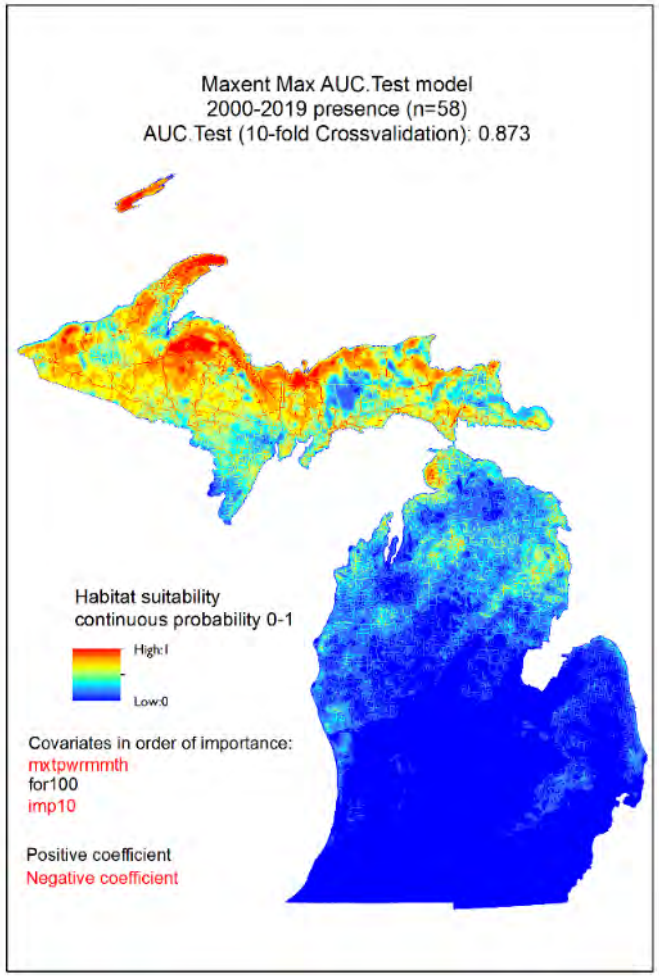
Bumble Bee Declines in Michigan

Bombus terricola

- Used species presence to inform models
- Evaluated over 150 environmental variables
  - Climate
  - Landcover
  - Terrain
  - Geology
  - Hydrology
- Used MaxEnt to evaluate predictor variables
- Used AUC test to determine best model



Species Presence



Suitable Habitat

Bumble Bee Declines in Michigan

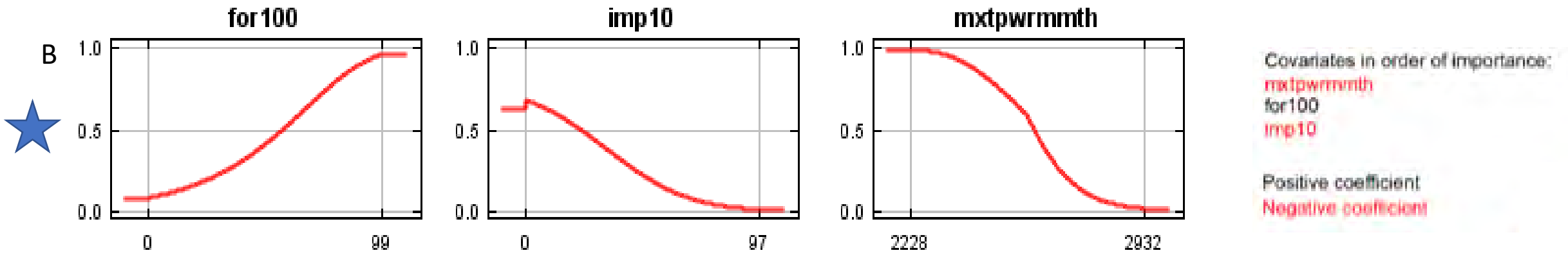


Figure 17. Variable response curves for environmental variables found to associated with suitable habitat for *B. terricola* in Michigan when variable is assessed independent of additional variables.

Rowe et al. 2019

Bumble Bee Declines in Michigan

- Eight species experiencing statewide population declines
- 6 species have not been seen in 20 years and are likely extirpated

B. auricomus

B. affinis

B. terricola

B. pensylvanicus

Setting Long-Term Goals

1. Reverse or mitigate the effects of habitat loss
   - Habitat conservation, enhancement, restoration, connectivity

2. Continue researching effects of bumble bee stressors on populations
   - Environmental: Climate change, landcover change, other abiotic?
   - Pathogens/Parasites spread
   - Pesticides

3. Develop long-term monitoring efforts to track populations through time
   - State level and National level

Ongoing Monitoring Initiatives

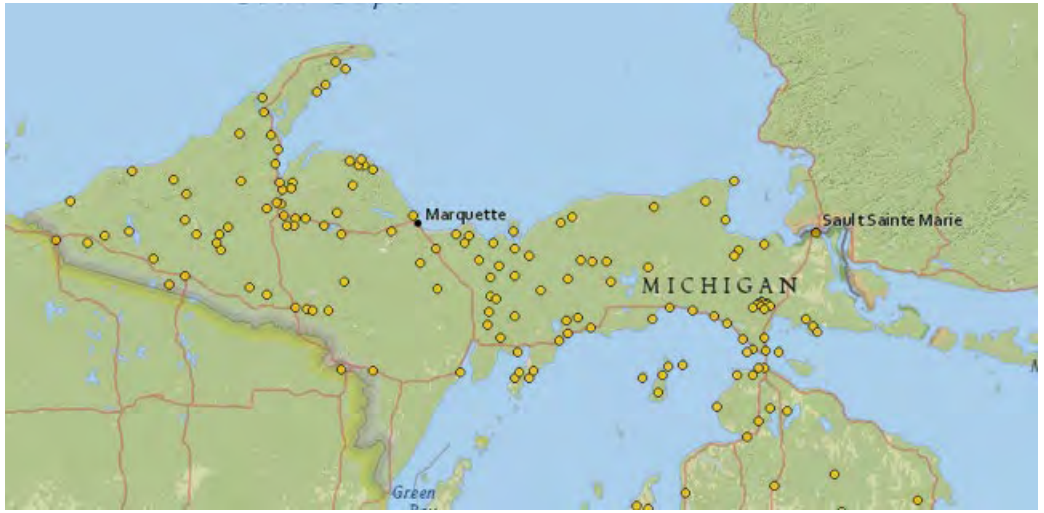
Southwest Michigan Bee Watch

- MNFI will continue statewide surveys 2020-2022!!!!

Surveys 2020-2022

B. affinis

- *B. affinis*: Re-evaluate historic sites (at least 30 sites)
- *B. terricola*: develop long-term monitoring plots (20 sites)
- Site selection criteria:
  1) landcover 2) time since last obs 3) # of adjacent obs



B. terricola

Stay Up To Date & Get Involved

Multiple species of Bumble bees are in decline across Michigan, prompting appropriate conservation actions at the State and Federal Level. In 2016, Bombus terricola (Yellow Banded Bumble Bee) was listed in the USFW Service 7-year National Listing workplan, and in 2017 B. affinis (Rusty Patched Bumble Bee) was added to the Endangered Species list. Both species are listed as Species of Greatest Conservation Need (SGCN) in the Michigan Wildlife Action Plan. MNFI is actively engaged in the long-term monitoring of at-risk bumble bee species in Michigan in an effort to understand and describe range shifts, and aide in the conservation efforts for these species.

Explore Michigan Bumble Bees

MNFI manages a statewide long-term data set of bumble bee occurrences across Michigan. The data shown here include historic and current observations from museum, academic, personal, and citizen science sources. Over 12,000 bumble bee records are included in the interactive map.

Go to the Map Viewer

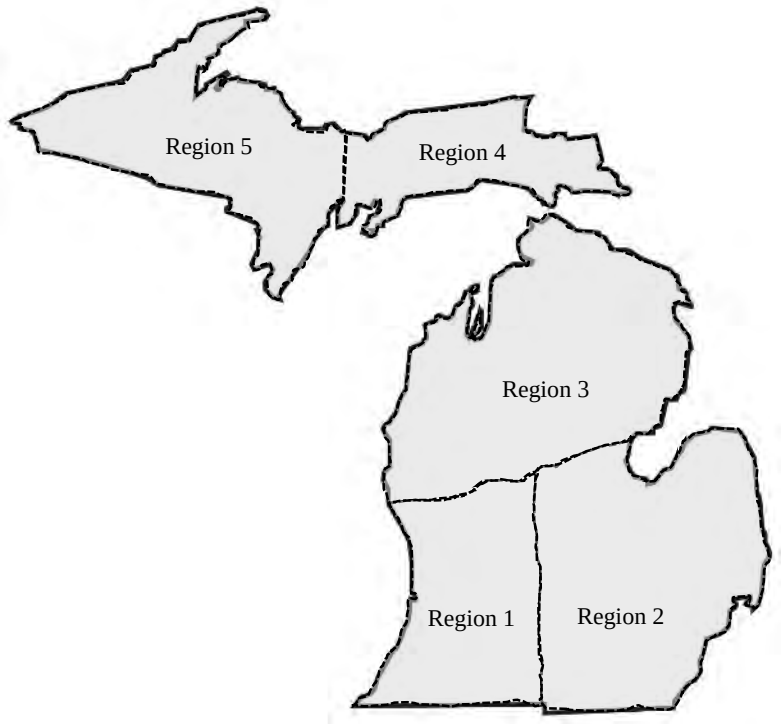
Our database is ever-growing. All data is available for use and can be obtained for research or general purposes. If you have bumble bee data and would like to share in this collaborative effort, please contact Logan Rowe at Roweloga@msu.edu.

For more information, please read our recent report titled: Assessing Bumble Bee Diversity, Distribution, and Status for the Michigan Wildlife Action Plan.

Get Involved - Michigan Bumble Bee Citizen Science Initiative

More information coming soon.

Michigan Bumble Bee Citizen Science Initiative



Regions of interest

For each observation:

Measurable Variable	Data Input Options	Primary Objective
Flower species bee was observed on	User input	Flower preference
Flower Cover in 10m radius	1-100 %	Resource availability
Number of flowering species in 10m radius	1-2, 2-5, 5-10, >10	Resource availability
Surrounding habitat	Roadside Developed park Garden Natural area Agricultural field Riparian area Woodland	Habitat association

Variables of interest

Please visit: https://storymaps.arcgis.com/stories/4e472238bbd44ed49b09c17a4c66fcfd

Sign up after presentation

Thank you for listening!

Contact: RoweL1@Michigan.gov