POLLINATOR PROTECTION PLAN

KEWEENAW BAY INDIAN COMMUNITY

Baraga County, Michigan

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Introduction

The preparation of this Pollinator Protection Plan is in fulfillment of grant funding received from the Bureau of Indian Affairs through the Great Lakes Restoration Initiative, Contract Number A18AV00581. In 2018, KBIC adopted a Terrestrial Invasive Species Management Plan to address the need for a Rapid Response Strategy to curtail the invasive insect *Drosophila suzukii*. The presence of this fruit fly causes accelerated deterioration of native fruits and therefore has serious consequences for strawberries, raspberries, blueberries, blackberries and more, upon which many community members rely upon for sustenance. With a growing commitment to practice Food Sovereignty, the potential loss of these nourishing native foods would have harsh consequences for the community. A gap in our knowledge is an awareness of the population of insects, the Manidoosh, *Little Spirits,* who are present within the L'Anse Reservation. To fill in this void, we contracted with an Insect Ecologist to conduct site specific pollinating insect surveys at our Sand Point Restoration Site and at our Debweyendan Indigenous Garden. Based on the survey results, this Tribal Pollinator Protection Plan was developed. A continuation of insect surveys is underway to mark the presence of both pollinating and non-pollinating insects.

At every moment the air we breathe is shared with the insect world. As the six-leggeds hum, chirp, and buzz they have much knowledge to share with us. They are part of a dynamic ecological reservoir and deepening our kinship with them, simply by being aware of their presence, is an excellent way to express our appreciation and respect toward them. Their companionship among the native plant species at our restoration sites help guide us to arrive at sound decisions in caring for our environment.

With this Pollinator Protection Plan we hope to be better prepared to receive teachings from the manidoosheg, and in turn be aware that the actions we take will be respectful and in response to protect and expand habitat for the insect community.

Appendix 1

Expanding our Ojibwa vocabulary is yet another step in connect to our world. Here is a compilation of insect names from the Ojibwa Dictionary and Red Lake School.

ant - enigoons
ant hill - bikwadaawangisin
bedbug - minaagojiisi
bee - aamoo
beehive - aamoo-wadiswan
beetle - moowijigesi
black fly - bikojiisi
bug - manidoons
bumblebee - mishaamoo
butterfly - memengwaa
caterpillar - odamwaabagwesi
crawler - bebaamooded
cricket - oojiigaaweshiinh
deerfly - mizizaakoons
dragonfly – oboodashkwaanishiinh
earthworm (1) - zhigwanaawis
earthworm (2) - moose gaa-bimaabiigizid
firefly – waawaatesi
fish fly - omiimiisi
flea - babig
fly - oojiins
gnat - babiigojiinsii
grasshopper – bapakine
hornet - aamoo
horsefly - mizizaak
house fly - oojiins
inchworm - diba'igenishiish
june bug - ojiingoskidewesi
louse lice - ikwa
maggots - ookwe
mayfly - omiimiisi
millipede - bayaatiinoogaaded
mosquito – zagime
moth - animikiiwidikom
spider – asabikeshiinh
stick bug - ojiichiidikomeshiinh
stink beetle - ojiingoshkidewesi
tapeworm - gaazhag
termite - mamiskojiisii
tick - ezigaa
water flea - babig
waterbug - omiskosii
water-strider - maangodikom
wooly bear caterpillar - miishijiizimwaabigwesi
wood tick - ezigaa
worm - moose

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1.0 Pollinator Types, Their status, Importance, Needs and Threats to Their Survival on kbic lands

1.1 pollinator overview

Pollinators are organisms that move pollen from one flower to another, allowing for cross-fertilization among individual flowers and plants. Pollinators are typically hairy or "fuzzy", which helps them collect pollen and move it around. While bees may be our most well-known pollinators, a great variety of other organisms provide pollinations services; from birds to bats, wasps, flies, beetles, butterflies and even moths. Worldwide, it is estimated that **pollinators (primarily insects) provide $235-577 million in agricultural services each year** (FAO, 2016), and this number is likely conservative.

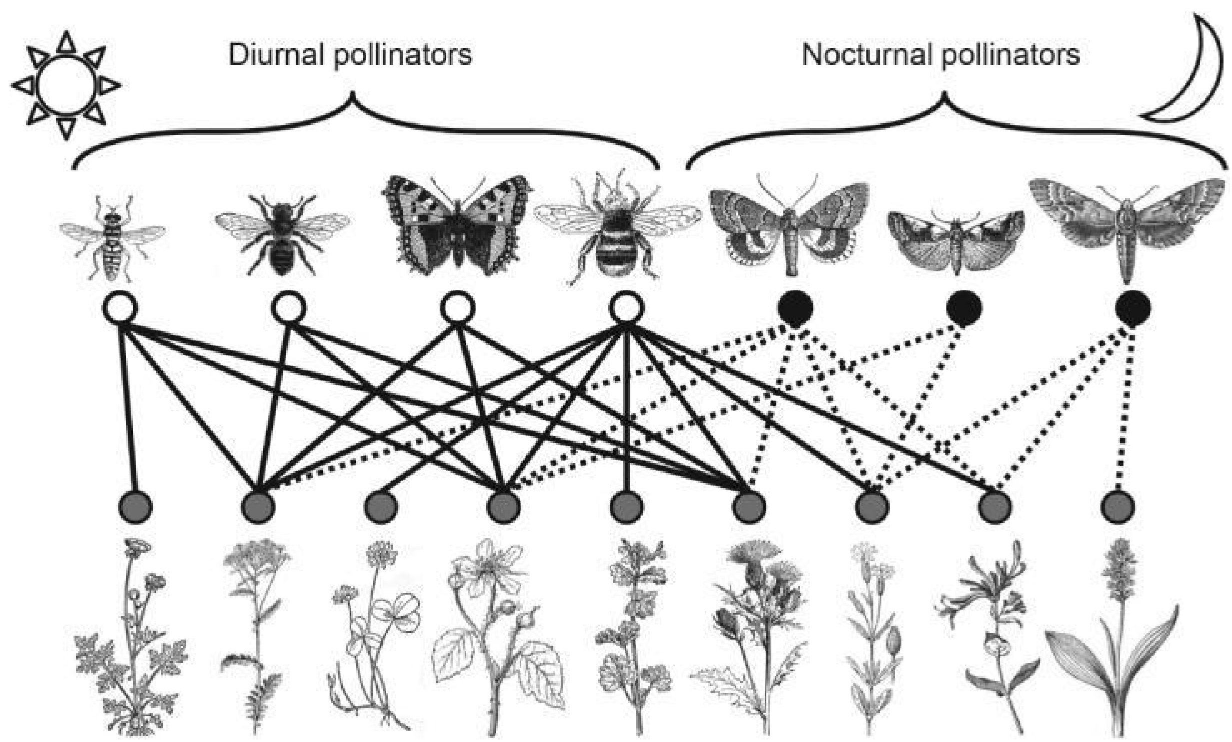

Figure 1. An example showing the diversity of daytime (diurnal) and nighttime (nocturnal) pollinators and redundancy in flower visitation among a local flora. (From: *MacGregor et al. 2015: Pollination by nocturnal Lepidoptera, and the effects of light pollution: a review. Economic Entomology*)

Insects are our most abundant and diverse pollinators and have been driving plant evolution for >400 million years. Many of the flavors, smells, tastes and effects we enjoy from plants were created by those plants to either repel or attract insects. Therefore, it should be little surprise that we have developed similar interests in plants over time. Insects pollinate a great variety of plants including many species that humans rely on for food and medicine (Garibaldi et al., 2014; Mader et al., 2010; Robertson, 1928). Honeybees have been domesticated and used for pollinating crops for thousands of years, while bumblebees have been domesticated for pollination services since at least the late 19th century. Here in Michigan, our native bees are vitally important for the commercial production of apples, blueberries, cherries, cucumbers, melons, pumpkins, raspberries, strawberries and tomatoes. In our gardens, they pollinate beans, peppers, tomatoes, peas, herbs and many other plants.

Pollinator surveys conducted on KBIC lands in 2020-2021 identified several species of native bees known to be important pollinators of Michigan fruit and vegetable crops (Bess, 2022). However, agricultural productivity should not be the only reason we are protecting our pollinators (Kleijn et al., 2015). In our fields, meadows, prairies, roadsides and woodlands, insects pollinate a great variety of wildflowers, including many species having culinary, medicinal and spiritual significance to a great variety of humans (Robertson, 1928). Many pollinator insects also provide additional environmental services like pest control, soil aeration and nutrient cycling.

1.2 Importance of Pollinators to Our Economic, Environmental and Spiritual Well-being

Because of their inherent usefulness, pollinators (esp. the honeybee) have been utilized by humans for many thousands of years. Our relationship with the honeybee has changed over the millennia, from first using wild ones as a direct food source (honey) to active domestication for honey production and pollination services in southeast Asia and Africa around 9,000 years ago (refs). Other social, honey-producing bees have been domesticated to varying degrees elsewhere in the world, particularly in the tropics.

1.2.1 The Bee Economy

Since their initial domestication, honeybees have been transported by humans to every continent except Antarctica, where they provide billions of dollars in revenue through their pollination services, and products like honey, bee pollen and beeswax. Here in the US, honeybees are used to pollinate numerous agricultural crops, which has led to an entire industry devoted to maintaining and moving bee colonies around the country to pollinate these fruits, vegetables and nuts. In particular, the $8 billion California almond industry relies almost exclusively on honeybees to pollinate their trees and produce almonds. These bees are now ubiquitous across the Americas and many farmers and gardeners maintain hives for pollination services, honey and beeswax. In many areas, humans still hunt for wild honeybee nests and raid these for honey, wax and bee immatures. Honeybees in the mountains of Turkey to the Himalayas collect supposedly psychoactive pollen from local Rhododendrons and a thriving business has arisen for locals to guide foreigners on hallucinogenic honey trips. This “mad honey” has been consumed and exported for thousands of years (Ullah et al., 2018; Wikipedia, 2021).

Bumblebees are another group utilized by humans for pollinating crops, particularly indoor, greenhouse fruits like strawberries and tomatoes (Figure 2). Bumblebees are the primary pollinators of tomatoes, peppers, strawberries and several other crops and their activities are known to increase fruit set and yield (Nayak et al., 2020; Banda and Paxton, 1991). In Europe, native bumblebee species have been used commercially to pollinate greenhouse crops since the 1980s. These commercial bumblebee colonies are transported around like honeybees and have now been "accidentally" introduced into several countries where they were not native. Here in the US and across the Americas, we use some of our native bumblebees (esp. *Bombus impatiens*) to perform the same tasks and this use has exploded since the early 2000s.

Figure 2. Domesticated bumblebee colonies used to pollinate greenhouse fruit crops, on the left strawberries and tomatoes on the right. The tomato operation is in Madison, WI and uses the native *Bombus impatiens*. Left photograph is from ArterraUIG via Getty Images, Right photo is by Clay Bolt)

Other native bee species are also used on an industrial scale for agricultural production, including mason bees (*Osmia* spp.) for spring-flowering fruit pollination. Alkali bee (*Nomia melanderi*) and alfalfa leafcutter bee (*Megachile rotundata*) colonies are raised and transported for alfalfa pollination – crucial to the commercial production of alfalfa seed for planting pastures and feeding livestock. Alfalfa leafcutter bees were brought over from Europe and are the second-oldest managed bee species in the Americas. Hundreds of additional native bee species also provide pollination services for a wide range of crops. Therefore, pollinator insects have become vital to sustaining local, regional and national economies.

Here in Michigan, more than 450 native bee species have been identified to date, making it one of the most diverse states in the Midwest (Gibbs et al., 2017). Many of these bees visit only one or a few species of flowers for nectar and pollen, including numerous crops like apples, blueberries, cherries, raspberries, serviceberries, squash, sunflowers and tomatoes. Several of these native bees have been proposed for use in crop pollination. However, our understanding of the environmental requirements of most of them are unknown and some appear to be locally or regionally in decline (Bartomeus, 2013; Colla et al., 2009; Brown and Paxton, 2009).

1.2.2 Importance of Non-bee Insect Pollinators

Among the non-bee insect pollinators, flies and wasps often receive negative attention or press, much of it unfounded. Despite this bad press, even some of our most annoying insect residents - the deerflies and horseflies, have males that do not feed on blood but instead quietly visit flowers to feed on nectar, moving pollen around in the process. The hover flies (family Syrphidae) are a large and important group of pollinators that contains many species superficially resembling wasps or bees, which provides them a degree of protection from predators but causes alarm among humans. In the summertime, they will hover close by and sometimes land on you - trying to lick the sweat off your exposed skin, but they are completely harmless. The larvae of these flies have a range of lifestyles, nearly all of them beneficial to humans. A large subgroup lives on plants, where they crawl around feeding on aphids and other small, soft-bodied insects. This provides many millions of dollars in biocontrol services in addition to their role as pollinators. Another large group of hoverflies has aquatic larvae that feed on dead and decaying plant matter, providing nutrient-cycling and carbon-sequestration services in the process.

Many pollinator flies and wasps also parasitize a wide variety of other insects, including many pest species, providing biocontrol services. Other pollinator wasp species, including yellow jackets and bald-faced hornets, are voracious predators on caterpillars and other soft-bodied insects. A large colony of bald-faced hornets or yellow jackets is removing hundreds of caterpillars and other insects from the local environment each day. These predatory and parasitic species provide billions of dollars in biocontrol services each year and dozens of species are commercially grown and released for this purpose. These include flies in the family Tachinidae and tiny wasps in the superfamily Chalcidoidea, many of which are commonly found on flowers, feeding on nectar and pollen, which they can then move around from flower to flower.

In turn, pollinator insects are food for a variety of other species, particularly birds and small mammals. A healthy environment supports a great diversity of plants and pollinators, along with their predators, parasites and other organisms. Some pollinator insects are even used as food, for cosmetics and/or medicine by humans and their livestock. Honeybee honey, wax, pollen and even immature bees are widely eaten or used in cosmetics and medicines. Stings from live bees are used to control chronic pain in certain individuals. Soldierflies (family Stratiomyidae) are related to hoverflies and are commonly found feeding on nectar from flowers, where they can act as pollinators. Black soldier fly larvae (*Hermetia illucens*) are decomposers currently being raised industrially in Europe and elsewhere for animal feed and other by-products. Efforts are now underway to market them for human consumption (Bessa et al., 2020).

1.3 Known and Potential Threats to Local and Regional Pollinators

1.3.1 Background on Pollinator Declines

Unfortunately, populations of many pollinator insects have been declining for at least the past 30-40 years throughout much of North America and elsewhere (Reilly et al., 2020; Potts et al., 2016; Bartomeus et al., 2013; Cameron et al., 2011; Brown and Paxton, 2009; Goulson et al., 2008; Klein et al., 2007; Colla et al., 2006; Winter et al., 2006; Packer et al., 2005). In 2006, US beekeepers began noticing mass die-offs in their overwintering honeybee colonies and this continued for several years before subsiding around 2014, only to resurge in recent years (USEPA, 2021a; Watters et al., 2021). In response to this initial decline in domesticated honeybees, the US Environmental Protection Agency (USEPA) held a series of meetings in 2008 to develop a "Pollinator Protection Strategic Plan" to guide the Nation's efforts in combatting declines in these vitally important organisms (USEPA, 2008).

The causes for widespread honeybee "colony collapse" are still not fully understood but are thought to relate to several factors including pesticides, stress from transportation, parasites/pathogens and loss of native pollen and nectar sources through land conversion. The invasive varroa mite (*Varroa destructor*) is considered a primary culprit in weakening bee colonies and exacerbating the effects of other stressors on honeybees. This colony collapse disorder led to widespread concern regarding bees, pollinators in general and global/local food security. Many national and international conferences were convened and a great variety of documents produced regarding pollinators, the threats they face and steps humans can take to minimize or even reverse some of these losses.

Also around this time, some bumblebee species that were once common throughout the eastern US showed signs of rapid population decline/loss across much of their former ranges (Cameron et al., 2011). For example, the rusty-patched bumblebee (*Bombus affinis*) disappeared from >87% of its former range in a couple of decades. The species was listed as Federally Endangered in 2017 (USFWS, 2021). Currently, the USFWS is assessing the American bumblebee (*Bombus pennsylvanicus*) for emergency listing as an endangered species (Center for Biological Diversity, 2021). This bee used to be common in much of Michigan, but recent surveys found it to be absent across most of the State (Rowe et al., 2019). Additionally, the yellow-banded bumblebee (*Bombus terricola*) has disappeared from much of its former range, including parts of Michigan (Rowe et al., 2019; Gibbs et al., 2017). Concurrently, these species have been functionally replaced by *Bombus impatiens* (Jacobson, 2017), a bumblebee widely used for greenhouse tomato and strawberry production. This bee has recently expanded its range in the UP (Rowe et al., 2019; Gibbs et al., 2017) and is now the most common bumblebee in the Keweenaw region, effectively replacing Bombus terricola.

Recent research strongly correlates the decline in U. S. bumblebee species with the intensification and homogenization of row-crop agriculture (Hemberger et al., 2021) and the use of Bombus impatiens and B. occidentalis in greenhouse fruit production (Manley et al., 2015; Cameron et al., 2011). A leading candidate for causing the collapse of several bumblebee species is a European pathogen (*Nosema bombi*) that was likely introduced into domesticated western bumblebee (Bombus occidentalis) colonies in the 1990s. Both domesticated and wild populations of the western bumblebee immediately began to crash and other closely-related bumblebees, like *Bombus affinis, B. pennsylvanicus* and *B. terricola* also began to show signs of widespread population distress, likely caused by the *Nosema pathogen*. These bees continue to decline in numbers and distribution across their former ranges and are in danger of extinction.

Additional insect pollinators have also experienced drastic population declines in the past four decades, in the US and elsewhere. Declines in butterflies (Warren et al., 2021) and moths (Conrad et al., 2006) have been noted in Europe. Here in the US, we have also experienced declines in our Lepidoptera biodiversity (Forister et al., 2021; Wagner et al., 2021; Swengel et al., 2011). Some of these species' plights, like the monarch butterfly, have been well-documented in the news and popular culture. Others have received less coverage, including charismatic little butterflies like the Poweshiek skipperling (*Oarisma poweshiek*). This species used to be locally common on prairie remnants in western Minnesota and the eastern Dakotas south into Iowa, with disjunct populations in isolated wetlands in southern Michigan and Wisconsin. The adults fly slowly over vegetation, taking nectar from flowers like black-eyed Susan (*Rudbeckia hirta*) and bog asphodel (*Triantha glutinosa*), while providing modest pollination services. The larvae feed on wetland sedges, rushes and grasses.

In the mid-2000s, researchers on Minnesota prairies noticed that, where they had once seen hundreds of these butterflies, they were now seeing fewer. This quickly reduced to a handful of individuals and then by 2014 (when the butterfly was emergency listed as federally endangered) they were gone from all but a few sites in southern Michigan (USFWS, 2021b). The causes of this range-wide population crash are poorly understood at present, but prime suspects include pesticide use, habitat loss and land management practices (Belitz et al., 2019). Michigan has several other rare, threatened and endangered pollinators, including the federally endangered Karner blue butterfly (*Lycaeides melissa samuelis*), the state-threatened northern blue (*Lycaeides idas nabakovi*) and ottoe skipper (*Hesperia ottoe*), state-endangered flower moths (*Schinia indiana* and *Schinia lucens*) and dozens of others threatened by habitat loss, pathogens/parasites, invasives species and other factors yet to be identified. Sadly, we have lost additional pollinators like the regal fritillary butterfly (*Speyeria idalia*), which was once widespread across southern Michigan and the northeastern U. S. until the late 1960s when it began to rapidly decline east of the Mississippi River. Today it is extinct in the State of Michigan and is known east of Illinois from a single population in NW Indiana and another in extreme western Pennsylvania.

1.3.2 Threats to Pollinators

The loss of pollinator species is having direct economic impacts on humans, as many of our pollinator-dependent crops appear to be "pollinator-limited", meaning a significant portion of their flowers go unfertilized and do not set fruit (Reilly et al., 2020). Currently, pollinators and other insects face a broad range of threats to their survival, from direct predation and parasitism to habitat loss, pesticides and climate change. While some of these are part of natural processes, others have been inflicted upon the natural world by modern human activity. Currently, the most important threats to the continued survival of our pollinators include:

- Loss of Habitat
- Pesticide Misuse
- Pathogens and Parasites
- Invasive Species
- Climate Change

Each of these threats is discussed in the following sections. It is quite likely that there is synergy among some or all these factors, with loss of habitat and climate change likely magnifying the effects of the others.

Loss of Habitat

Habitat loss through conversion to agricultural or urban/industrial uses is the primary existential threat facing all organisms, humans included. Here in the US, European colonization, settlement and westward expansion in the 1700s-1800s profoundly changed the American landscape. Great forests were reduced to fields of stumps and many millions of acres of dried slash, left over from these clearcuts, burned in massive fires during the late 1800s and early 1900s. Resulting erosion clogged streams and rivers with sediment and millions of acres were left essentially sterile through loss of topsoil. This is especially notable on the sandy soils of northern Michigan and Wisconsin, where a few inches of topsoil, that had taken thousands of years to develop, was removed in a matter of days or weeks.

Our once vast savannas, barrens and prairies were rich pollinator habitats, but most have been converted to cropland, forest, cities or subdivisions, and are now reduced in acreage by 80-99%, nationwide (Hill and Barone, 2018; Noss, 2012; National Wildlife Federation, 2001; Nuzzo, 1994; Sampson and Knopf, 1994). Wildfires, which formerly burned through many prairie and savanna habitats, were aggressively controlled starting in the late 19th century. This came about largely because of the human response to the horrific fires that resulted from clearcutting of the Upper Great Lakes region in the late 1800s and early 1900s. This cessation of natural fire led to the rapid succession of formerly open, pollinator-friendly areas to shrub thickets and closed-canopy woods with little resources for pollinators. Wetlands were ditched, drained and/or filled, often with government backing. These habitats collectively supported thousands of pollinators and other species, many of which are now rarely observed on the human-altered landscape.

Pesticide Misuse: The Pesticide Wars

Pesticide misuse is a chronic threat to pollinators and the general health of our environment. The term “misuse” is chosen because certain pesticides, when used properly, can be effective in controlling pest plants and insects. However, the widespread application of pesticides across the landscape over the past 60-70 years has helped bring on many of the environmental crises we face today. In the recent past, millions of acres of wetland, fields, forests, towns and villages were blanketed with a fog of DDT to control mosquitoes or forest pests, removing all other insects (and many birds) in the process. Vast tracts of forest and crop land were (and are) also sprayed with a great variety of other hazardous insecticides to control pests, often killing off many beneficial insects and negatively affecting birds, bats and other insectivorous animals. Edges, pastures and ditches were/are sprayed with herbicides to control "weeds", many of which were/are important resources for pollinators.

Today, we use different chemicals, but this spraying goes on, unabated. Pest insects are constantly evolving immunity to certain pesticides, so new ones must be formulated to attack these new threats. The arrival of Bt (*Bacillus thuringiensis*) in the 1960s was hailed as a great improvement in insect control, as it is a naturally occurring soil bacterium that can be grown commercially and its toxins biosynthesized. Bt is marketed as a "natural" insecticide and is approved for use on organic-certified crops. Another feature of Bt is that it is somewhat selective, with various strains supposedly killing only certain groups of insects. Two of these insect groups, Lepidoptera (butterflies and moths) and Diptera (the flies) are highly susceptible to Bt toxin, with near 100% mortality in exposed individuals. Therefore, Bt has been very effective in controlling a variety of crop pests and health hazards, like mosquito-transmitted illnesses. However, the Diptera and Lepidoptera contain many fascinating and highly beneficial pollinator and biocontrol species and are two of the largest orders of Insects. We know next to nothing about their contribution to the health and well-being of our natural systems, but both groups are known to contain species experiencing recent population declines.

The rise of suburbia and competitive lawn care following World War II created an explosion in the "lawn care" industry, with manicured monocultures of non-native grass becoming the mass-marketed ideal for all homeowners. According to this doctrine, lawns must be sprayed with fertilizers, weed killers and insecticides to keep them uniformly green. Mowing and "weed" removal are regular maintenance activities. These vast tracts of identical monocultures are hostile deserts to most pollinators and other wildlife. As a result, suburban sprawl is a leading factor in the continued reduction of natural area acreage and the endangerment of native vegetation and wildlife, worldwide.

As mentioned previously, the primary loss of pollinator habitat has been through conversion of natural areas, pastures and old fields to intensive row-crop agriculture. Major shifts in American farming practices took place in the 1950s and again in the 1980s, although for different reasons, yet both were detrimental for native vegetation, pollinators and other wildlife. Following WW II, the growing population needed commodities like meat, dairy, wheat and corn, requiring more land to be farmed to meet ever-increasing demand. New machinery allowed for more acres to be tilled, while new pesticides, fertilizers and plant breeds brought greatly increased yields. Government incentives encouraged maximizing production and yield. Large areas of virgin prairie and savanna were tilled all over the US between 1950-present to grow these and other crops. Native grasslands and meadows were overgrazed and replanted with Eurasian pasture grasses and clovers, further reducing diverse, native habitat acreage for pollinators and other wildlife.

In the not-too-distant past, most US farms were small (100 acres or less) and diverse, meaning they had multiple types of crops, some livestock and areas of fallow land that were either too dry, rocky, or wet to effectively farm. Hayfields, containing a mix of native and Eurasian plant species, were common and provided pollinator habitat. Field edges and fence rows were largely left untouched, other than occasional seasonal burning or mowing to control shrubs and pests that overwintered there. These marginal lands held great biological diversity and were essential for the survival of many species.

Unfortunately, the American financial system of the late 1970s-1980s was not kind to farmers; many went bankrupt, land values plummeted and banks failed. By the 1990s, surviving farmers and investor groups began buying up small farms, packaging groups of them together and shifting to a “maximized-return-on-investment strategy”. This involved ripping out fencerows and woodlots, draining wetlands and turning groups of once diverse, small farms into huge monocultures of corn, wheat, rice, cotton or soybeans. These crops require millions of gallons of pesticides to protect from insect damage every year and water to irrigate growing plants. Concentrated animal feeding operations (CAFOs) are blamed for much of this shift in agriculture, as these huge concentrations of animals require constant sources of feed and water. This strategy of industrial farming has only increased in acreage over the past decades, with millions of acres of pollinator habitat lost in the process.

Tied in with this shift in agriculture has been the development of things like “RoundUp-Ready” crops, i.e., crops that are immune to the effects of Glyphosate, the active ingredient in the herbicide RoundUp and related herbicides. This allowed farmers to spray Glyphosate-containing herbicide on or around their crops without negative effects. Glyphosate inhibits photosynthesis and is typically lethal to all green plants. This has led to the destruction of what little remained of native vegetation along many field edges, ditches and roadsides across the U. S. Roadside ditches, fencerows and railroad rights-of-way often contain the last scraps of native vegetation in intensively agricultural landscapes and provide the only means of connectivity between widely scattered, “protected” natural area remnants. Destroying or damaging marginal habitats and small remnant natural areas leads to the rapid loss of local biodiversity (Wintle et al., 2019). Currently, the herbicides Dicamba and 2,4 D are causing chaos in agricultural and adjacent natural systems through damage or mortality of non-target vegetation resulting from pesticide drift. These herbicides are lethal to plants and highly volatile, able to maintain toxicity for extended periods of time in the air and on soil (OSU, 2021). Numerous farmers and other land owners have filed lawsuits against adjacent landowners because of crop loss and habitat damage.

Among the most recent development in the pesticide wars is a new class of insecticides known “Neonicotinoids” which, as their name suggests, are derived from chemicals related to nicotine in tobacco. These neurotoxic pesticides were game changers, in they could be applied to seeds prior to planting and, when the plants germinated, they would take up the chemicals systemically, making all parts toxic to insect herbivores. This toxicity can transfer to nectar and pollen resources, meaning these chemicals can harm pollinators that feed on treated plants. Nicotine and related compounds are lethal or highly disruptive to insects, even at low exposure rates, and neonicotinoid pesticide exposure has been shown to disrupt bumblebee and honeybee nest behavior, social networks, and thermoregulation (Crall et al., 2018; Tosi et al, 2017). It is widely believed that this class of herbicides has been among the largest drivers in recent insect population reductions, from bees to butterflies and moths. A study on Colorado native bees (from native grassland and agricultural settings) found they were carrying high levels of residues representing numerous insecticides, particularly neonicotinoids (Hladik et al., 2016).

Nursery-grown bedding plants and pre-packaged seeds (including fruits, vegetables and flowers) are/were typically treated with these chemicals. When the seeds germinate, the growing plant acquires the pesticides in its tissues, making them hazardous or lethal to herbivore and pollinator insects. In 2013, 54% of commonly purchased bedding plants at major retailers contained neonicotinoid residues (Friends of the Earth, 2013). Activists have sounded the alarm on this matter and home improvement chains like Home Depot, Lowes and Walmart have committed to ending the use of these chemicals in the plants that they sell. Unfortunately, seeds are still treated with these chemicals and product labeling often does not state whether these chemicals were used. An on-going, major source of incidental damage from these insecticides is the “dust” that comes off seed when bags are unloaded into crop planters. This dust can drift and land on plants and soil, with the insecticides then becoming incorporated into tissues of non-crop plants.

Pathogens and Parasites
The colony collapse outbreak of the mid-2000s was caused at least in part by varroa mites that feed on honeybees. Mite numbers can build up in dirty or unhealthy hives, reducing bee fitness and weakening the colony. These mites can also carry viruses that infect bees, further weakening and even killing them. Additional viruses, fungi and bacteria can infest brood cells, destroying entire generations of young. Pathogens and parasites can also be transmitted among colonies when bees from different hives visit the same flowers. Moving colonies from site to site also stresses and weakens bees, making them more susceptible to pathogens in their new environment. Sick bee colonies can then be vectors of diseases when moved into new areas and, in the case of commercial bee pollination, this can occur with many other hives, sometimes from different locations.

In bumblebees, the pathogen *Nosema bombi* was historically known only from Europe, where it had varying effects on different bumblebee species, being highly lethal to some species. This pathogen was transported to the Americas via imported European bumblebees sometime in the 1990s. Commercial colonies of bumblebees can harbor increased loads of this and other pathogens, which can then be transmitted to local, native bumblebee populations (Cameron et al., 2011; Otterstater, 2008; Colla et al., 2006; Goka et al., 2006, 2001). In other countries, bumblebee populations have crashed following the widespread use of *Bombus terrestris* in greenhouses and the presumed transfer of pathogens from those bees to native ones. However, some of these bees were previously in decline because of habitat loss.

Here in the US, the use and transport of native bumblebees for greenhouse fruit production is strongly implicated in the population crashes of several native bumblebee species, esp. *Bombus affinis, B. occidentalis, B. pennsylvanicus* and *B. terricola* (Cameron et al., 2011). All were once common across large portions of the US prior to the 1980s. In their 2011 study, Cameron and associates found highly elevated levels of *Nosema bombi* in populations of all four of these *Bombus* species and not in currently stable ones like *Bombus bimaculatus* or *B. impatiens*. A strict moratorium on the importation of non-native bumblebees into the US was recommended in 2006 (Winter et al., 2006) but was never codified into law.

The common bumblebee *Bombus impatiens* has been widely used in greenhouses across the US and is known to harbor low levels of *Nosema bombi* (Cameron et al., 2011). This could make it a vector for *Nosema bombi*, spreading this or other pathogens among the flowers it (and other bumblebees) visit. These researchers found *Bombus occidentalis* and *B. pennsylvanicus* also have reduced genetic diversity or occur in smaller, widely distributed populations, making them more susceptible to localized extinctions. Regardless of the cause, populations of these four formerly common and widespread bumblebees have crashed in the past 20-30 years.

Invasive Species
Invasive species are here described as "organisms out of place" or occurring outside of their normal range and exhibiting aggressive growth or behavioral characteristics that negatively affect other organisms native to that region. Among the non-native animals brought to the US over the years, one of the species that has had a profound negative effect on pollinators is the spongy moth (*Lymantria dispar*). Deliberately brought to Massachusetts in the early 1800s as a potential source of silk, the moths quickly escaped confinement and began to spread across the eastern US (Bess, 2004; Schweitzer, 2004). They have few natural predators or parasites here in the Americas, allowing them to rapidly build up populations. Their outbreaks defoliate large areas of forest, removing food for other insects, including pollinator species (esp. butterflies and moths). The larvae will feed on more than 400 species of tree, shrub and herbaceous plant and have caused millions of dollars in losses through property damage and tree mortality.

These losses have resulted in a widespread campaign by humans to at first eradicate, then suppress the spongy moth's march across the landscape. This campaign has involved the aerial spraying of insecticides across millions of acres of forest land, towns and villages, typically killing most insects in the target area. As part of Integrated Pest Management (IPM) protocols, dozens of non-native, parasitic flies and wasps have been introduced in an attempt to control this (and other) insect pest species. Up until a few decades ago, this was often done with little screening regarding cross-over to non-target species. Most of these introductions have had limited success in controlling the pest species they were meant to target.

What this has done is to increase the number of parasitic species in areas where they were released, often feeding on non-target species. In New England, large silk moth and sphinx moth populations were decimated by this combination of spraying and parasites and have yet to recover in many areas. A tachinid fly (*Compsilura concinnata*) that was brought over from

Europe in 1906 and released by the millions to control the spongy moth is considered responsible for much of this reduction. In addition to feeding on spongy moths, these flies found many of our larger, native moths and butterflies to also be delicious and have been negatively affecting their fitness ever since. Here in Michigan, it was associated with reductions in Canada tiger swallowtail populations back in the 1990s (Bess pers. obs.; Redman and Scriber, 2000). This large, bristly, noisy fly can be very common and annoying during UP summers, esp. when they land on bare arms or faces to feed on sweat.

Invasive plants also pose a serious problem to pollinators and environmental health in general. There is a long history of humans bringing non-native plants to the New World, and these plants then escaping into the surrounding environment. The rise of suburbia in the 1960s brought about the rise of landscaping and nursery industries, ready to cater to Americans with newly found disposable income and yards to decorate. Many of the shrubs, trees and flowers for sale through these vendors were not native to the Americas or were heavily modified cultivars of what were once native plants. From the 1800s through the 1980s, there was little or no regulation on what plants could be brought into the country and sold. Many species were brought here, cultivated and subsequently escaped into the general environment, with many causing chaos in local ecosystems.

Pasture development and restoration is another area where non-native plant species have been deliberately brought to the US and then spread from cultivation to the detriment of pollinators and other native species. As European settlers moved across the continent in the 18th and 19th centuries, they brought their non-native grazing animals with them. These animals required a steady supply of herbaceous vegetation to feed on, so natural meadows and prairies were targeted at first, with additional clearing of forest for pasture expansion and lumber production. As time went on, herds grew and many areas were grazed at unsustainable rates, leading to death of the vegetation, followed by widespread erosion of topsoil and loss of land fertility. To combat this, seed of Eurasian grasses (long used in old world pastures) were brought over to control erosion, "restore" and re-seed these pastures. Non-native clovers were often included in these seed mixes to provide additional forage and nitrogen-fixation.

Three of the most common upland pasture grasses here in the northwoods; Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*) and smooth brome (*Bromus inermis*) are not native to our region. Another commonly planted grass, creeping red fescue (*Festuca rubra*), is made up mostly of Eurasian cultivars. In wetter pastures and meadows, reed canarygrass (*Phalaris arundinacea*) and a non-native cultivar of giant reed (*Phragmites australis*) were planted for fodder and to reduce erosion and siltation of waterways. Several of these species can form dense sods and at least some have allelopathic qualities, discouraging the growth of other plants. All are now ubiquitous in natural and disturbed areas throughout the Midwest.

In allegiance with agriculture, the horticultural industry has worked diligently on plant genetics and cultivation for thousands of years, supplying a dizzying array of flowers and vegetables to place in our yards and gardens. While many are benign or even beneficial to pollinators, others have escaped cultivation and spread across the landscape, excluding native flora in the process. Among the more noxious escapees here in the UP are garlic mustard (*Alliaria petiolata*), knapweed (*Centaurea stoebe*), several thistles (esp. *Cirsium arvense, C.palustre, C. vulgare*), purple loosestrife (*Lythrum salicaria*), tansy (*Tanacetum vulgare*) and wild parsnip (*Pastinaca sativa*). Many of these were intentionally introduced in the past and grown widely as herbs or for their flowers. Their general occurrence shows a broad tolerance for soil types and moisture content, allowing them to readily move into a variety of open and/or closed-canopy habitats.

Tansy and wild parsnip contain chemicals that can cause severe skin rashes in humans if touched, and all species appear to produce allelochemicals that impede the growth of other plants. These invasives often form large monocultures in disturbed habitats, before moving into natural areas. All five of these plant groups represent varying degrees of potential conflict regarding pollinators. While they eliminate native vegetation with their aggressive growth, they also provide nectar and pollen resources for pollinators. This can even have economic repercussions when restoration efforts are undertaken; beekeepers in certain areas have complained strongly about spotted knapweed removal efforts because it is the primary pollen and nectar source for their bees. Throughout much of the dry, sandy portions of Michigan, spotted knapweed is a primary “wildflower” on the landscape for much of the summer and it is increasing its coverage annually. Here in the western UP, marsh thistle is very common in ditches and along damp paths, where it is typically covered in pollinators while in bloom. Creeping thistle (*Cirsium arvense*) and bull thistle (*C. vulgare*) can be abundant in old fields and degraded pastures. These thistle species bloom for months, produce thousands of seeds and attract large numbers of pollinators. Therefore, to prevent further damage to our pollinators and the economies they sustain, efforts to remove these plants from the land must be paired with re-vegetation and habitat improvement efforts that provide adequate pollinator nesting and floral resources.

Climate Change

Climate change is the specter overshadowing the future for our pollinators and life on earth in general. Here in the Midwest, projections are calling for increases in average temperatures and precipitation, with a corresponding increase in extreme and extended “heat events” (Winkler et al., 2014). The climate of the Lower Peninsula of Michigan is projected to become more like that of southern Ohio or even Oklahoma, depending on varying levels of continued greenhouse gas emissions. The UP is projected to become warmer and drier; with longer, hotter summers and shorter winters. The entire state is projected to experience a five-fold increase in extreme heat days by 2050 (States at Risk, 2021). Ongoing climate change will continue to have profound effects on our flora and fauna, likely amplifying the negative effects of other threats to biodiversity, like loss of habitat and exposure to parasites, pathogens and poisons.

1.4 Current Status of Pollinators on KBIC Lands

From late August of 2020 through fall of 2021, an intensive pollinator survey was conducted on select KBIC lands by Dr. James Bess from Northland Environmental Services, LLC (Bess, 2022). The sites surveyed were the Community Gardens in L’Anse and the Sand Point Dune Restoration in Baraga. Primary pollinator insect orders were targeted, including the Diptera (flies), Hymenoptera (bees and wasps) and Lepidoptera (butterflies and moths). This survey effort identified more than 470 species, including many moths (317 species), butterflies (50 species), bees (45 species), flies (28 species) and wasps (20 species). This survey added many new records for Baraga County and several new records for the Upper Peninsula of Michigan. Several species recorded during this survey are rarely encountered and are of conservation concern locally and regionally. The following are discussions of the major pollinator groups found on KBIC Lands.

1.4.1 Domesticated Pollinators – Honeybees

Domesticated honeybees were observed at both sites throughout our surveys, but were much more common at The Gardens, where there are actively maintained hives. Bumblebees were common at both sites but much more abundant and diverse at The Garden. Extensive forest, edge and old field habitat nearby likely offers more nesting opportunities for these bees here than at Sand Point.

1.4.2 Wild and Native Bees

Over 3,600 species of native bees occur across North America, with more than 460 of these recorded from Michigan (~230 in the UP: Gibbs et al., 2017), making it one of the most diverse states for bees in the Midwest. Bees are especially well-adapted for collecting and transporting pollen, with most having their bodies covered in dense, branched hairs resembling tiny spruce trees. Native bees use this collected pollen and nectar from flowers to provision their nests for feeding their young. These bees build their nests in a variety of places, including tunnels in the soil, hollow plant stems, burrows in old logs, leaf piles, gaps in masonry, rock piles or even cracks and nail holes in old buildings.

A great variety of native bee species were observed during the 2020-2021 pollinator surveys, including many new county records, several that are new records for the UP and two that are new to science. A few of these bee species are even of conservation concern. A total of 45 bee species were recorded from the two sites, including:

- 27 new bee species records for Baraga County,
- 7 new bee species records for the UP, and
- 2 bees new to science, being described and are “new” to the state list.

Gibbs et al. (2017) identified 465 species of bees from Michigan, with 228 of those recorded from UP counties. Those researchers initially noted 35 species from Baraga Co. and, with the 27 additions from the recent KBIC study, there are now 62 species recorded from the County to date. This brings the total closer to more heavily collected counties like Alger (89 species total), Keweenaw (89), Marquette (97) and Mackinac (88). Baraga County likely has many more bee species to be revealed, as the recent KBIC study indicates.

Sand Point had the greatest diversity of bees, with 36 species observed, primarily in the dune restoration and along roadsides; The Gardens had 22 species and both sites had species not present at the other. The Community Gardens site was particularly rich in bumblebees, including healthy-appearing populations of two rare species, the northern golden bumblebee

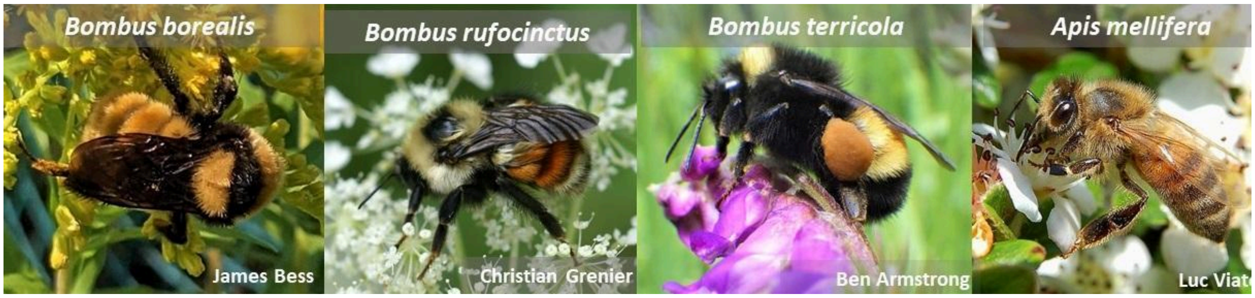

Figure 3. Bees of the Family Apidae observed at the two sites in 2021, from L to R: *Bombus borealis, B. rufocinctus*, *B. terricola* and the honeybee (*Apis mellifera*).

(*Bombus borealis*) and the red-belted bumblebee (*Bombus rufocinctus*) shown in Figure 3. A queen of the increasingly rare Bombus terricola was also observed at The Community Gardens in 2021. All three species are listed as Special Concern by the Michigan Natural Features Inventory (MNFI), which maintains records on Michigan's flora, fauna and remnant natural areas. This listing provides no legal protection but indicates these species are of conservation concern and that MNFI is maintaining records for future evaluation.

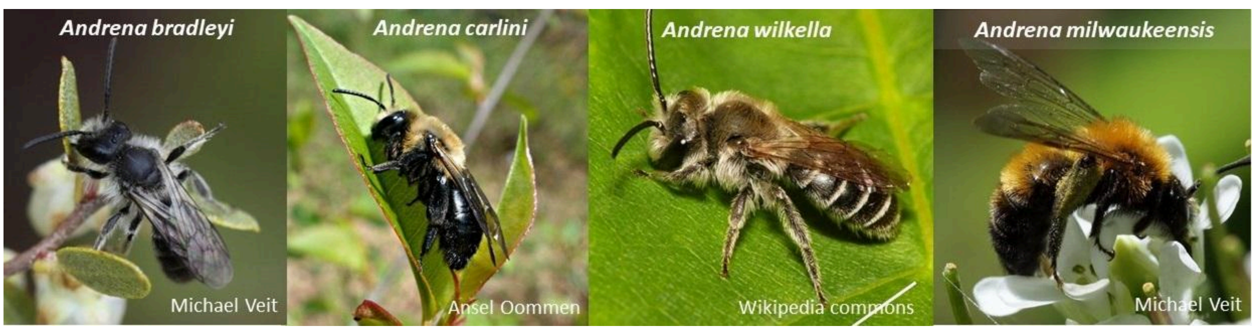

Figure 4. Bees in the family Andrenidae observed on KBIC lands. From L to R, photos by Michael Veit, Ansel Oommen, Wikimedia Commons and Michael Veit.

Other notable KBIC bee species include the economically important digger bees *Andrena bradleyi, Andrena carlini, Andrena crataegi* and *Colletes inaequalis* (Figure 4). All nest in tunnels dug into areas of bare, sandy soils and are important pollinators of apples, blueberries, cherries, plums, serviceberries and strawberries, among other crops and many wild plants. *Andrena bradleyi* is a blueberry/Ericaceae specialist, while Gibbs et al. (2017) report *Andrena carlini* as the most abundant wild bee on Michigan apples, highbush blueberries and tart cherries. In eastern Canada, nests of this species were also provisioned with strawberry pollen, indicating this bee is an important pollinator of those fruits as well (Gibbs et al., 2017; Schrader & LaBerge 1978). *Andrena cratagei* is also among the most abundant native bees on Michigan apples and tart cherries, but females fly a bit later, making them less effective pollinators of these crops in some areas (Gibbs, 2017). However, this was among the earliest bee species observed on KBIC lands in 2021, flying by May 12th in the fens at Sand Point. The introduced, Eurasian *Andrena wilkella* is a reported alfalfa/Fabaceae specialist and was observed at Sand Point on alfalfa (*Medicago*), white sweet-clover (*Melilotus*) and yarrow (*Achillea*). An additional notable Andrenid bee was *Pseudopanurgus aestivalis*, a new record for the Upper Peninsula of Michigan. This generally uncommon species is reported as a specialist on asters and goldenrods, but the single specimen collected in 2021 was taken at chickweed (*Cerastium*) at The Gardens.

In the family Colletidae, *Colletes inaequalis* was abundant at Sand Point in May, with a large nesting aggregation of hundreds of females in the north parking lot (Figure 5). This is an abundant and important pollinator of many spring-flowering crops and wildflowers, including apples, blueberries and cherries. An undescribed species of yellow-faced bee (*Hylaeus* nr *modestus*) was recorded from The Gardens. The more common *Hylaeus annulatus* was found at Sand Point. These tiny, wasp-like bees prefer a mix of flowers, esp. carrots, their relatives and certain mints. Raspberries and strawberries are also commonly visited. Sweat bees (family Halictidae) were surprisingly uncommon during the 2020-2021 pollinator surveys, represented

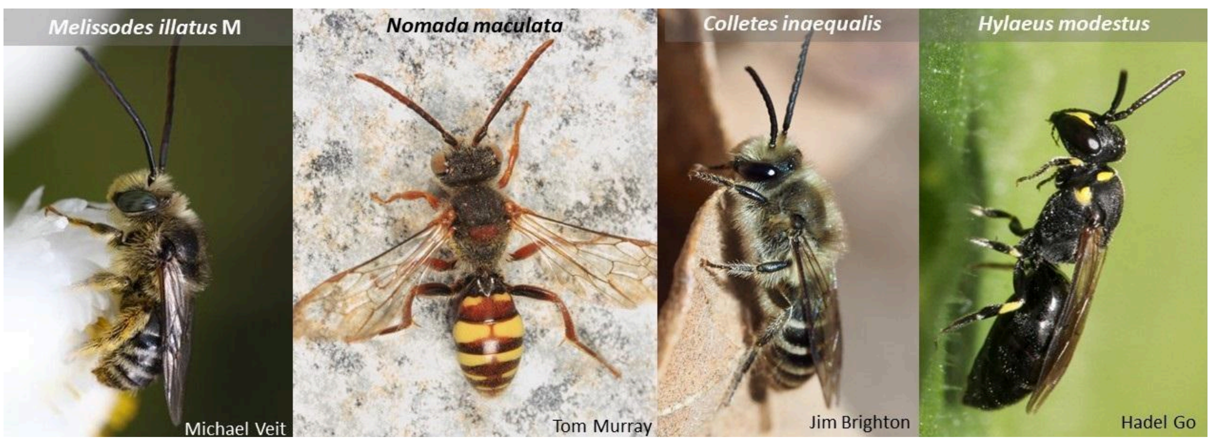

Figure 5. Bees of the families Apidae and Colletidae observed in 2021. From L to R: *Melissodes desponsus* and Noma*da maculata* in the Apidae, *Colletes inaequalis* and *Hylaeus modestus* in the Colletidae.

by three species of *Halictus* (*H. confusus, H. ligatus* and *H. rubicundus*) and a couple *Lasioglossum* (*L. leucozonium* and *L. pilosum*) shown in Figure 6. The drought during much of summer may have affected their numbers, as it greatly reduced nectar sources in July and August. These bees visit a great variety of plants, esp. in the families Asteraceae, Brassicaceae, Fabaceae, Lamiaceae and Rosaceae. All three *Halictus* are common, wide-spread species that nest communally (typically in large numbers) making them locally important pollinators wherever colonies are found. They are thought to be among the most primitive "social" bees. *Lasioglossum leucozonium* is a Eurasian introduction that is now abundant across much of North America, while *L. pilosum* is a common eastern native bee.

Figure 6. Various sweat bees (family Halictidae) common in the Keweenaw region. From the left – *Agapostemon* sp. (photo via NCSU); *Halictus* sp. (via DiscoverLife); *Lasioglossum* sp. (via dalantech_der7oaz); and *Halictus* sp. (via Wikipedia).

Leafcutter and mason bees (family Megachilidae) were the largest, most diverse family of bees found on KBIC Lands (Bess, 2022). Leafcutters get their name from their skills at cutting semicircular sections of leaves and using them to build intricate, multi-celled nests in burrows made in old logs, driftwood, plant stems and the soil. They are a very diverse group (>4000 species worldwide: >630 in North America) and occur on all continents except Antarctica. Megachilidae are distinctive among the bees in that the “scopa” or pollen carrying structure is located on the underside of the abdomen (Figure 7). These bees are out from early spring through fall and are important pollinators of a great variety of plants, esp. in the families Asteraceae (asters, sunflowers, etc.), Fabaceae (beans, peas, etc.) and Rosaceae (apples, cherries, raspberries, strawberries, etc.). *Megachile latimanus* and *M. relativa* were the most

Figure 7. Leafcutter bees *Osmia georgica* (L) and *Hoplitis spoliata* (C) showing pollen-carrying hairs (scopa) on underside of abdomen (Photos by Michael Veit). On right is *Anthidium manicatum* (photo via Wikipedia).

frequently observed, while *M. pugnata* was slightly less common but very frequent across the Keweenaw region (Figure 8). *Megachile latimanus* digs nesting tunnels in sandy soils, while *Megacile relativa* nests in plant stems and old insect burrows in wood. *Megachile pugnata* typically burrows into old logs or uses abandoned insect borings. Both *Megachile relativa* and *M. pugnata* readily utilize reed, bamboo and bored wood block trap-nests. *Megachile pugnata* visits a great variety of flowers but prefers Asteraceae and has been assessed for industrial pollination of sunflowers (Gibbs et al., 2017). Rare or notable Megachilidae include *Heriades carinata*, *Megachile inermis* and *Osmia albiventris*, all of which are reported as declining across all or much of their former ranges. Some introduced/non-native Megachilidae were also observed in 2021, including the European wool-carder bee (*Anthidium manicatum*) and the alfalfa leafcutter bee (*Megachile rotundata*).

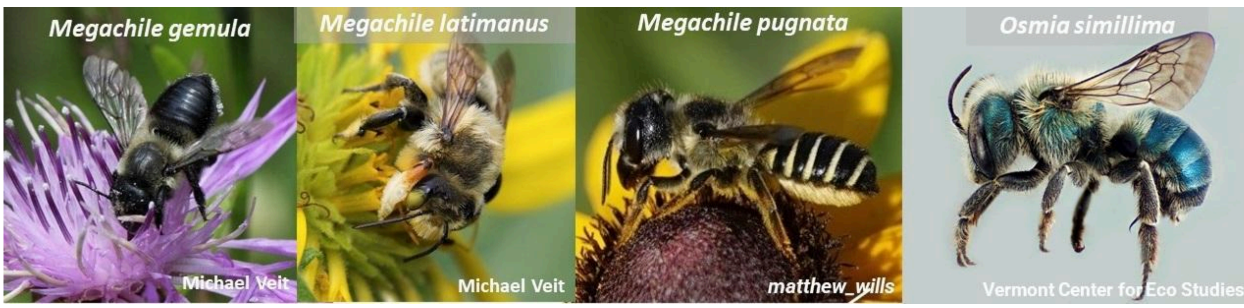

Figure 8. Bees in the family Megachilidae found on KBIC Lands in 2021. From L to R; *Megachile gemula, M. latimanus, M. pugnata* and *Osmia simillima*. Photos by Michael Veit, Mathew Willis and Vermont Center for Ecological Studies.

1.4.3 Butterflies

A total of 50 butterfly species were observed during our surveys in 2020-2021. Most of these are common in the Northwoods, like the Canadian Tiger Swallowtail (*Papilio canadensis*), Little Wood Satyr (*Euptychia cymela*), Mystic Skipper (*Polites mystic*), Northern Pearl Crescent (*Phyciodes cocyta*), Sulphurs (*Colias eurytheme* and *C. philodice*) and the White Admiral (*Limenitis arthemis*). All of these except the Little Wood Satyr are common flower-visitors. Compton's Tortoiseshell (*Nymphalis vau-album*), mourning cloaks (*Nymphalis antiopa*) and green commas (*Polygonia faunus*) were common (especially at Sand Point) in the fall of 2020 and spring of 2021. Both feed on rotting fruit sap and animal droppings as adults. *Satyrium liparops* is typically a species of oak barrens and open woodland, where the larvae feed on foliage of various shrubs like *Amelanchier*, *Prunus*. Adults feed on nectar from a variety of wildflowers and a single female was observed nectaring on white sweet clover along the road through the pine barrens in the Ojibwa Recreation Area. This butterfly is widespread but tends to be uncommon and local. The unadorned ringlet (*Coenonympha inornata*) was abundant in the grassy fields at The Gardens in June and early July. This species is typically uncommon and local, so this population is regionally significant, as hundreds of individuals were observed during peak flight. Two characteristic boreal peatland butterfly species were observed at Sand Point, the Bog Copper (*Lycaena epixanthe*) and the Jutta Arctic (*Oeneis jutta*) shown in Figure

10. Both are widely distributed but become increasingly uncommon and local in occurrence at the southern edge of their ranges, which includes northern Michigan.

Figure 9. Butterflies observed at the study sites, from L to R; Arctic Skipper (*Carterocephalus palaemon*: photo by Haeferl), Summer Azure (*Celastrina neglecta*: photo by M Nicolai), Great-spangled Fritillary (*Speyeria cybele*: photo by Phil Meyers) and Inornate Ringlet (*Coenonympha inornata*: photo by Ryan Hodnett).

The monarch butterfly (*Danaus plexippus*) is probably our most well-known butterfly and its recent declines have been much covered by news sources. The caterpillars feed only on milkweed, a group of poisonous plants found all across North America. The caterpillars and adult butterflies acquire protection from many predators by absorbing these chemicals into their bodies, making them very distasteful. Loss of habitat has greatly reduced monarch numbers across the U. S., and they were uncommon at the KBIC Lands surveyed in 2020-2021. This scarcity is likely because of the general rarity of milkweed at the two sites. The blueberry sulphur (*Colias interior*: Figure 10) was observed at Sand Point in low numbers in July. The larvae feed on blueberries.

Figure 10. Additional butterflies observed at the study sites. From L to R: jutta arctic (*Oeneis jutta*: photo via janzack at ButterfliesandMoths.org); bog copper (*Lycaena epixanthe*: via Tom Murray); blueberry sulphur (*Colias interior*: via Norbert Kondla); and striped hairstreak (*Satyrium liparops*: via malcolmgold).

1.4.4 Moths

Moths are a huge but often-overlooked group of pollinators that likely provide billions of dollars in untallied environmental and agricultural services every year. There are more than 11,000 species of moths in North America and recent surveys on KBIC lands identified more than 300 species, with many more to be discovered. The hawkmoths or sphinx moths (family Sphingidae) are probably the best-known flower-visiting moths, pollinating many flowers with long floral tubes that match their long tongues. These moths are large and strong flyers, able to cover large areas while foraging. They often feed at dusk and are easily observed by humans. However, two much larger families of small to medium-sized moths, the Geometridae and Noctuidae, provide the greatest variety and quantity of pollination services for the environments they occupy. Each contains tens of thousands of species, many of which are known to visit flowers where they collect and distribute pollen while feeding on nectar (Walton et al, 2020; MacGregor et al., 2015).

Moths: Family Geometridae

The Geometridae have long been overlooked as pollinators, yet recent research has shown they are lured to floral extracts known to attract other pollinator moths in the family Noctuidae (Landolt et al., 2011). Genera containing species attracted to floral lures and therefore likely pollinators include:

- *Digrammia* (incl. ***Macaria, Speranza***)
- *Epirrhoe*
- ***Euchlaena***
- *Idaea*
- ***Iridopsis***
- ***Nematocampa***
- ***Orthonama***
- ***Pero***
- ***Prochoerodes***
- *Sericosema*
- *Synaxis*
- *Triphosa*
- ***Xanthorhoe***

Genera in **BOLD** were recorded during the 2020-2021 surveys on KBIC Lands.

Several of these groups are large and/or have closely related genera that are also likely flower visitors and pollinators. Many Geometridae are known for being able to fly at very low temperatures (35-45F), aiding their ability to pollinate flowers. These factors, coupled with long flight periods and/or multiple generations per year, indicate that the Geometridae are an important group of pollinators in natural and human-altered ecosystems.

The majority of the Geometridae we discovered during our surveys are common species for our region. However, one – *Macaria* (*Speranza*) *loricaria* is a western montane species, occurring north into the Yukon. Records east of the Rockies are rare and there are only two prior records from Michigan, both Otsego Co in the 1960s. The single specimen collected at Sand Point represents the first recent record for Michigan and a new record for the UP and Baraga County. The larvae feed on trembling aspen (*Populus tremuloides*).

Moths: Family Noctuidae

The moth family Noctuidae was especially well-represented (>200 species) and is one of the largest, most diverse groups of organisms on the planet. This family contains thousands of species known or suspected of being pollinators, including pollination of many agricultural and wild food crops. More than 3,000 species of Noctuidae are known to occur in North America (Fauske, 2007) and this diverse family thrives in many environments on all continents except Antarctica but is especially rich in grassland and desert habitats. Adults of many species feed on nectar from flowers and fluids from rotting fruit, tree sap and water from puddles. Larvae feed on a great variety of plants, shrubs and trees and the family includes some of the world's major agricultural pests, like armyworms (*Pseudaletia* and *Spodoptera* spp.), budworms (*Helicoverpa* and *Chloridea* spp.) and "cutworms" that attack young plants. They also serve as primary food sources for many birds, herptiles and small mammals. Larvae of the fall armyworm (*Spodoptera frugiperda*) have even been used in biomedical research to develop vaccines against viruses like influenza and the new SARS COVID-19 (Keegan et al., 2021).

Several subfamilies within the Noctuidea are known to contain species that visit flowers and serve as pollinators, given their furry heads and thoraxes that readily collect pollen (Robertson et al., 2021; Walton et al., 2020; Esposito et al., 2017; Petterson, 1991). These moths are attracted by floral scents and researchers have found various floral extracts attracted a great variety of them (Landolt et al., 2006, 2007, 2011). The large subfamilies Amphipyrinae, Cuculliinae, Hadeninae, Noctuinae and Plusiinae all contain known pollinator species. A great variety of flowers are visited, including important crops, and often by a suite of moth species from different groups/subfamilies. Robertson and fellow researchers (2021) found two species of moths, *Peridroma saucia* (Noctuiinae) and *Pseudaletia unipuncta* (Hadeninae) are major nocturnal pollinators of apple crops in Arkansas. The moth's activities increased fruit and seed set in apples, greatly improving yield. Some moth pollinators (like *Peridroma* and *Pseudaletia*) are also important agricultural pests as larvae, making our relationships with them complex.

While the family contains some important agricultural pests, it also has a far greater number of species known to be restricted in occurrence to high-quality natural area remnants. Many of these have become very rare on the landscape because of habitat loss, pesticides and other factors, making them of conservation concern throughout much or all of their former ranges. Several of these were recorded during the recent surveys, primarily from Sand Point (Bess, 2022). The following sections cover each of the major Noctuidae subfamilies encountered and notable pollinator or rare species are discussed.

Moths: Family Noctuidae - Subfamily Amphipyrinae
The Amphipyrinae are a group containing many species that are borers as larvae and live in wetlands or grasslands. The genus *Apamea* is a large group of medium-sized moths that occur primarily in wetlands, where their larvae feed on grasses like *Cinna, Glyceria, Spartina* and *Zizania*. Adults feed on nectar and are known to pollinate a variety of flowers, including milkweeds, orchids (*Platanthera* spp.), raspberries, pinks (*Silene* spp.) and clovers (Walton et al., 2020; Petterson, 1991, Peterson et al., 1981; Nilsson, 1978). Given the widespread destruction of our wetlands, several moths in this subfamily are currently rare regionally or globally. The coastal peatlands ("fens") at Sand Point are of extremely high natural area quality and appear to hold a very diverse moth fauna containing rarely or uncommonly observed species. Notable Amphipyrinae recorded during our surveys include *Apamea apamiformis*, *A. cogitata, Apamea impulsa, A. verbascoides, Conservula anodonta, Hypocoena inquinita, Papaipema appassionata, P. lysimachiae* and *Photedes panatella*. Several of these (and other wetland moths) were also taken at light traps in the restored wetlands, indicating that restoration efforts are now

providing habitat for a great variety of insects and other organisms. Leopard frogs (*Lithobates pipiens*) of all ages were also common in this wetland area throughout much of the summer, indicating they are reproducing in the local ponds and feeding on insects in the restored areas.

Figure 11. Notable moths in the subfamily Amphipyrinae (family Noctuidae) recorded from KBIC lands in 2021. From L to R: *Apamea apamiformis* (photo via Janice Steifel), *Papaipema appassionata* (via Tea Montagna), *P. lysimachiae* (via Jim Eckert) and *Photedes panatela* (via Tom Murray).

Apamea apamiformis (Figure 11) is a wetland species rarely observed since the 1970s. This beautiful moth has been known as “the wild rice worm” and implicated in commercial wild rice (Manoomin: *Zizania aquatica*) losses in Minnesota (Peterson et al., 1981). Indeed, this species was reared from wild rice in Ontario back in the 1950s (MacKay and Rockburne, 1958) and there have been
continued reports of the larvae from the commercial wild rice areas of Minnesota (Dahlberg and Pastor, 2014; Peterson et al., 1981). However, in their 2008 report to the State Legislature on Natural Wild Rice in Minnesota, the MN State Department of Natural Resources did not list the wild rice worm among the threats to wild rice production in the State (MN DNR, 2008). Despite extensive surveying in appropriate habitat for over 40 years, I have encountered this species only three times (as single individuals) including at Sand Point in 2021. All three occurrences were in high quality grassland/wetland complexes and two had no wild rice.

There are 24 additional *Apamea* species in the Upper Midwest, several of which are common within the historic range of wild rice, and all are likely pollinators. The life history of many of these is unknown or poorly understood, but all are known or thought to feed on grasses as larvae, which are similar in appearance between species. Other than the initial paper describing the life history and Peterson’s 1970s work in Minnesota, none of the subsequent reports indicate larval species identifications were verified or that adults were reared and retained for identification. These factors indicate there may be more than one species feeding on wild rice. Studies to determine the population size and distribution of this (and other moths) at Sand Point are recommended, esp. regarding their potential negative effects on local Manoomin cultivation. Given the moths visit the Manoomin flowers when they are actively producing pollen, it is likely they also serve as pollinators for this grass.

Several species of *Apamea* were encountered during our surveys, especially at Sand Point. *Apamea cogitata* is a western montane and boreal species found in more upland habitats like wet meadows. *Apamea impulsa* and *A. verbascoides* are boreal wetland species that can be locally common in high quality grass and sedge-dominated wetlands. *Apamea indocilis* is a widespread, Holarctic species, but very local in occurrence and generally uncommon. *Conservula anodonta* is another very rarely observed species found in swampy wetlands with lots of sedges and ferns, where its larvae feed on *Osmunda* ferns and alder (*Alnus*) (BugGuide, 2021b). A single individual was taken from the peatland area at the south end of the Sand Point dune restoration area. The record from Sand Point represents one of 5 for the UP and 7 for the State of Michigan. *Hypocoena inquinita* is another species of sedge-dominated wetlands, sometimes locally common in high quality habitats where the larvae bore into sedges like *Carex stricta*.

Papaipema appassionata (the pitcher plant borer moth: Figure 11) feeds as a larva in the roots of the purple pitcher plant (*Sarracenia purpurea*) which is locally common in the coastal fens at Sand Point. Larval feeding sign was observed in numerous *Sarracenia* clumps and adults were flying in August. *Papapipema lysimachiae* is another beautiful wetland species whose larvae bore into the basal stems and roots of *Lysimachia*, esp. swamp candles (*L. terrestris*). *Photedes panatella* is another wetland species with larvae that are stem borers in sedges. A few specimens were taken in the sedge meadow along US-41 at the N-end of Sand Point. The introduced European “rosy rustic” (*Hydraecia micacea*) is apparently common around The Garden, as several adults were taken 2020-2021. This species is spreading west from its initial importation in eastern Canada and can be a pest in the larval stage, boring into young corn and potato stems.

Moths: Family Noctuidae - Subfamilies Cuculliinae and Noctuinae (in part)

The Cuculliinae and portions of the Noctuinae contain many species that emerge as adults in the fall, overwinter as adults, then reappear early in the spring to mate and lay eggs on developing vegetation. These moths visit a variety of flowers, tree sap, rotten fruit, and puddles of water, while the larvae feed on the young foliage of a variety of trees and shrubs. The larvae of these moths are often among the most abundant early summer caterpillars in forests and woodlands, providing important food for nesting songbirds and small mammals. Important genera include *Eupsilia, Lithophane, Psaphidia*, *Pyreferra* and *Xylena*. Species encountered during our surveys include *Copivaleria grotei*, *Eupsilia sidus, E. tristigmata, E. vinnulenta, Feralia comstocki, Lithophane bethunei, L. grotei, L. innominata, L. semiusta, Metalepsis salicarum, Pyreferra pettiti, Xylena curvimacula* and *X. thoracica.* Most of these were taken in traps baited with rotten fruit, while others were taken at lights. Red maples and willows flowering in early spring are important food sources for these moths.

Members of the genus *Cucullia* proper are relatively large moths, with adults out in early summer and larvae that feed on various Asteraceae and are often very colorful. These pollinators were represented on KBIC lands by *Cucullia postera*, a primarily western species with scattered records in the Upper Great Lakes and Northeast, and isolated high elevation populations in the central Appalachians. A single male was taken at The Garden in late June. It is likely other members of this genus occur on KBIC Lands.

Moths: Family Noctuidae - Subfamily Hadeninae

Recent revisions of the former family Noctuidae have cut this family into groups and placed many species into the subfamily Noctuinae. I am staying with the older version of Hadeninae. This group is known to contain many genera that are attracted to fruit or floral extracts, have been observed pollinating plants or are attracted to rotten fruit. These include:

Caradrina	*Fishia*	*Mamestra*
Coranarta	***Helotropha***	*Mesogona*
Chytonix	***Homorthodes***	***Mythimna***
Dargida	***Lacanobia***	***Neoligia***
Egira	***Lacinipolia***	***Oligia***
Enargia	***Leucania***	***Spodoptera***

*Genera in **BOLD** were found during our 2020-2021 surveys*

Figure 12. Moth pollinators in the Noctuidae: subfamily Hadeninae known from the Keweenaw region. From left: *Coranarta cordigera* (photo via laji.fi), *Chytonix sensilis* (via Patrick Coin), *Lacanobia grandis* (via butterfliesandmoths.org), *Leucania ursula* (via Tom Murray) and *Oligia bridghamii* (via Wikipedia).

Notable Hadeninae found during recent pollinator surveys include *Anarta cordigera, Lacanobia grandis, L. nevadae, Leucania insueta, L. multilinea, L. pseudargyria, Melanchra pulverulenta, Nephelodes minians, Oligia modica, Polia imbrifera, P. nimbosa, P. purpurissata, Pseudaletia unipuncta* and *Sutyna privata* all of which are known or potential pollinators. *Anarta trifolii* (the clover cutworm), *Nephelodes minians* (the bronze cutworm) and *Pseudaletia unipuncta* (the armyworm) are important agricultural pests as larvae, yet the adults are pollinators of certain crops. *Leucania insueta, L. multilinea, Melanchra pulverulenta* and *Sutyna privata* are boreal wetland/peatland species, with *L. insueta* and *M. pulverulenta* being rare and local in occurrence, typically in high quality peatland remnants. The others are common species of the northwoods.

Moths: Family Noctuidae - Subfamily Noctuiinae

Many species in the subfamily Noctuiinae visit flowers as adults. Some, like the "miller moth" (*Euxoa auxilliaris*) occur across large stretches of the arid west. These moths make long migrations from their spring emergence and nectaring sites in valley floors up into the mountains to aestivate through the hot dry summer under rocks above tree line. These moths are a major summer food source for local grizzly bears (*Ursus arctos horribilis*) and other animals. Several Noctuine genera were identified by Landolt et al. (2011) as being attracted to floral and fruit extracts were also found during recent surveys, including *Abagrotis, Agrotis, Diarsia, Euxoa, Feltia* and *Xestia*. At Sand Point, *Euxoa detersa* and *E. scandens* were commonly observed nectaring on *Euthamia* and *Solidago* during the daytime (Figure 13). At night, these *Euxoa*, along with species of *Actebia, Feltia*, *Xestia* and related genera can be found in large numbers nectaring on *Centaurea, Doellingeria, Euthamia* and *Solidago* flowers (J. Bess, pers. obs.). They are also attracted to milkweeds (*Asclepias* spp.) and fireweed (*Chamerion*), along with large Noctuiinae like *Eurois astricta* and *E. occulta*. *Eurois occulta* has also been reported feeding at the flowers of *Chamerion latifolium* in the arctic (Encyclopedia of Life, 2021). The introduced *Noctua pronuba* was very common at The Garden and its larvae are large cutworms.

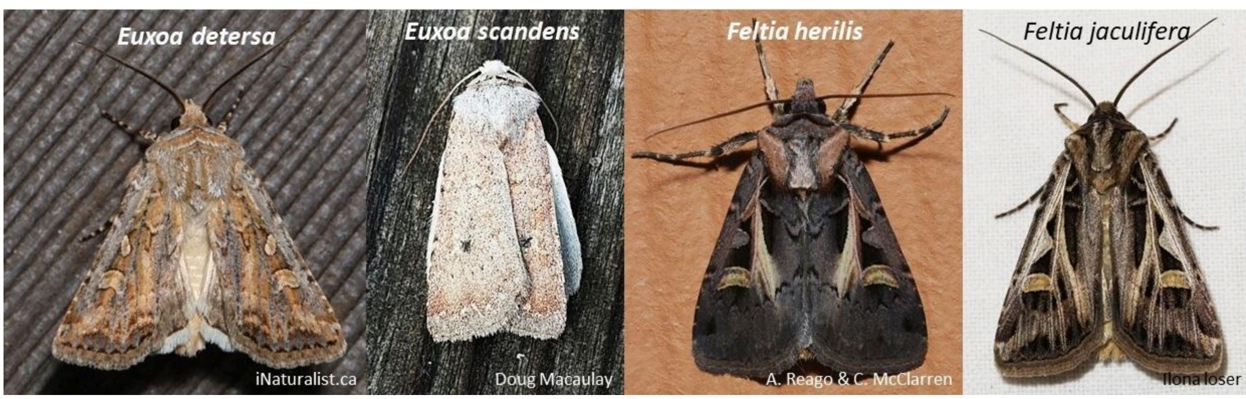

Figure 13. Common moth pollinators in the subfamily Noctuinae (family Noctuidae) observed on KBIC lands. From left: *Euxoa detersa* (photo via Jim Bess), *Euxoa scandens* (via Doug Macaulay), *Feltia herilis* (via Reago and McClarren) and *Feltia jaculifera* (via Ilona loser).

Several uncommon or rare members of this subfamily are also likely pollinators at Sand Point (Figure 14), including *Anicla forbesi*, *Eueretagrotis sigmoides*, *Euxoa mimallonis, E. scholastica, E. pleuritica, E, sinelinea, E. velleripennis* and *Hemipachnobia monochromatea*. There are few recent (1980s –> present) Michigan records for most of these species and all are new records for Baraga Co. *Anicla forbesi* and *Eueretagrotis sigmoides* are local and uncommon species of northern barrens and woodlands, while *Euxoa mimallonis* and *E. pleuritica* are western montane moths with scattered populations in the Upper Great Lakes and Northeast. All are typically found on dune deposits in Michigan, with the two *Euxoa* usually near the coast of Lakes Michigan and/or Superior. *Euxoa scholastica* and *E. velleripennis* are typically more southern species, usually associated with barrens and open woodlands where they are generally local and uncommon, esp. *E. scholastica*. Multiple individuals of both species were observed.

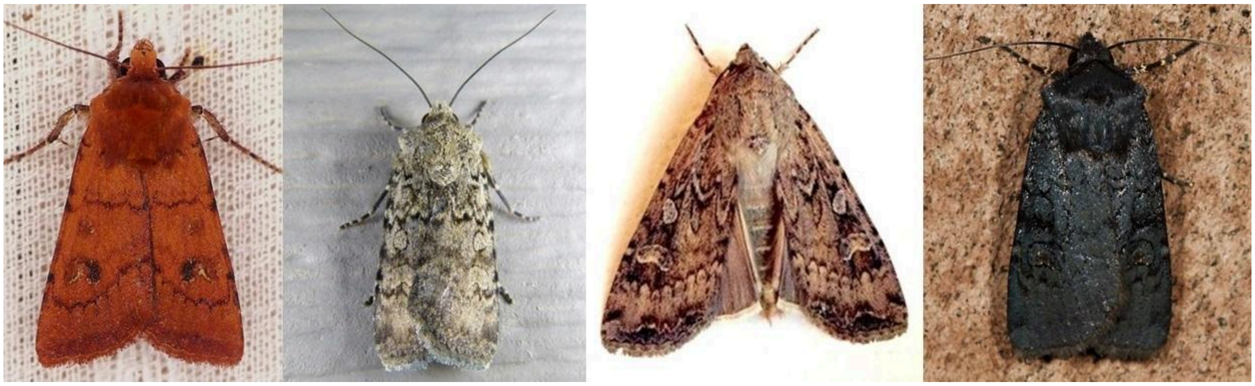

Figure 14. Notable *Euxoa* species (Noctuidae: Noctuinae) recorded in 2021. From L to R; *Euxoa mimallonis* (phot via Stewart Tingley)*, E, scholastica* (via Marcie Oconnor, Prairiehaven)*, E. pleuritica* (via Elin Pierce) and *E. velleripennis* (via Tom Murray).

Euxoa sinelinea and *Hemipachnobia monochromatea* are boreal peatland species, with *E. sinelinea* being especially rare in collections. It was described from type material collected in NE Canada (Hardwick, 1965), although most material currently in collections comes from northern Michigan. The sundew dart, as its name implies, feeds as a larva on sundew and cranberry foliage. This moth is generally local and becomes much rarer towards southern Michigan, near the edge of its range.

Moths: Noctuoidea - Subfamily Plusiinae

Members of the colorful subfamily Plusiinae have been known flower-visitors for many years (Nielsen, 1981; South, 1939; Figure 15). Only more recently have they been identified as important pollinators for a variety of plants, especially orchids (Sakagami and Sugiura, 2019; A. Nilsson, 1983; Hammarstedt, 1980; Nilsson, 1978). Throughout our region, they also readily visit milkweeds (*Asclepias* spp.), fireweed (*Chamerion angustifolium*), Joe-pye weeds (*Eupatorium* spp.) and asters (genus *Symphiotrychum*) (Bess, pers. obs.; Nielsen, 1981 and pers. comm). It is likely they are important pollinators of these species as well. Floral nectar resources are considered important drivers of natural selection for plants requiring pollinator insects (Brzosko and Bajguz, 2019). Nielsen (1981) recorded 20 species of these moths and the subfamily was common in our surveys, including 18 species:

1	***Allagrapha aerea***	10	*Plusia contexta*
2	*Anagrapha falcifera*	11	***Plusia magnimacula***
3	***Autographa ampla***	12	*Plusia venusta*
4	***Autographa bimaculata***	13	***Syngrapha altera***
5	***Chrysanympha formosa***	14	***Syngrapha epigea***
6	***Diachrysia aereoides***	15	*Syngrapha microgamma*

7	***Diachrysia balluca***	16	***Syngrapha octoscripta***
8	***Eosphoropteryx thyatiroides***	17	***Syngrapha rectangula***
9	*Exyra fax*	18	***Syngrapha viridisigma***

*Species in **BOLD** were reported on fireweed by Nielsen, 1981.*

Figure 15. Rare or uncommon pollinator moths in the subfamily Plusiinae (family Noctuidae) known from the Keweenaw region. From L to R: *Autographa bimaculata* (photo via Larry de March)*, A. mappa* (via Greg's Moths)*, Diachrysia balluca* (via Greg's Moths) and *Eosphoropteryx thyatiroides* (via Jim Eckert).

Their larvae feed on a variety of herbaceous plants like meadow rue (*Thalictrum*), as well as shrubs (*Alnus, Rubus*) and trees (*Betula, Populus*). The adults of many species appear to be long-lived, flying for two weeks or more, and are out from early summer until killing frosts in the fall.

1.4.5 Flies

More than 26 species of flies were observed or collected on flowers during recent surveys. The Bombyliidae (bee flies) were well-represented, with ten species identified and several others observed but not collected - large Bombyliidae were observed flying rapidly through vegetation on the edge of the exposed sands at Sand Point. These were very wary, nearly impossible to capture and likely looking for insect burrows in which to lay their eggs. Bee flies visit many flowers and their larvae are parasites on a variety of insects, including ground-nesting bees and wasps, grasshopper eggs and ground-burrowing beetle and moth larvae.

Female bee flies "throw" their eggs down the burrows of their hosts, using "cups" formed by bristles at the ends of their abdomens. Their larvae then hatch and climb onto whatever insect they find in the burrow, typically feeding on the larvae, eggs, pupae and/or food stores. *Paravilla separata* (Figure 16) was taken at Sand Point and is oligolectic on black-eyed Susan (*Rudbeckia hirta*), meaning it only feeds on flowers of that plant. Two species of broad-headed flies (family Conopidae) were also found, including *Physocephala furcillata* at both sites and *Physocephala texana* only at Sand Point. These flies spend lots of time on flowers and parasitize burrowing bees and wasps. Their presence indicates a healthy pollinator insect population at both sites.

Figure 16. Pollinator flies known from KBIC Lands. From L to R: *Paravilla separata* (photo via Angela Moorehouse), *Physocephala furcillata* (via Wikipedia), *Criorhina nigriventris* (via NYNHP) and *Cylindromyia interrupta* (via Wikipedia).

Flower flies (family Syrphidae) were very common, especially at Sand Point where they outnumbered bees on some days. No fewer than 13 species were observed, including many common northern wetland and upland species. *Criorhina nigriventris* is a boreal species listed as rare in Ontario. A single adult was taken at Sand Point, nectaring on leatherleaf flowers in the coastal fen in early May. This fly is an excellent mimic of the common boreal bumblebee *Bombus ternarius*. The genus *Eristalis* was very common around the fens in mid to late summer, especially on nodding burr marigold (*Bidens cernuus*) in ditches along the north access road. In the Tachinidae, the important subfamily Phasiinae were represented by *Cylindromyia interrupta*. These flies resemble small red and black wasps and parasitize a variety of Hemiptera, including many agricultural and garden pests. Some species are even raised commercially for release to combat crop pests like squash bugs. Another Phasiine, *Gymnosoma canadense,* was observed on several occasions at Sand Point and parasitizes a variety of Hemiptera, especially stink bugs (family Pentatomidae).

1.4.6 Wasps

KBIC Lands appear to have a good diversity of pollinator wasps, with >20 species collected or observed and identified in this survey effort. Sand Point especially stands out as excellent habitat for these insects, many of which burrow into sand to make their nests. These important insects serve “double duty” as both pollinators and as predators/parasites of a great variety of other insects, including many crop pests. Many species we typically think of as nuisances – yellow jackets, paper wasps and mud daubers, are pollinators AND remove huge numbers of caterpillars, spiders, grasshoppers and other agricultural pests from the environment every year. In the huge solitary wasp family Crabronidae, the sand digger wasp *Bembix americana* feeds almost exclusively on deerflies and horseflies. These grayish-looking wasps will sometimes follow humans around on hot days, trying to catch the biting flies that are pestering us. This can be a bit unnerving until you realize what they are doing! Their bright green eyes are distinctive and amazing (Figure 17). They dig tunnels in sand and fill them with deerflies and horseflies to feed their growing young. Additional Crabronidae at Sand Point include:

- *Anacrabro ocellatus* (provision nest with plant bugs - Miridae)

- *Cerceris fumipennis* (provision nest with wood boring beetles - Buprestidae)
- *Ectemnius* sp. (provision nest with medium-large flies - Diptera)
- *Pemphredon inornata* (provisions nest with planthoppers and leafhoppers - Homoptera)
- *Philanthus gibbosus* (bee wolves; provision nests with bees - Hymenoptera: Apoidea)

Figure 17. Pollinator wasps known from KBIC Lands. From L to R: *Bembix americana* (photo via Paul Sabino), *Ammophila* sp. (via Wikimedia Commons), *Leucospis affinis* (via Marvin Smith) and *Philanthus* sp. (via Wikipedia).

In the huge superfamily of tiny parasitic wasps (the Chalcidoidea), several individuals turned up in the small sweep sample from Sand Point and these wasps are common components of most intact ecosystems. Though most are likely too small to carry a lot of pollen around, one notable species was taken from flowers – the leafcutter bee parasite *Leucospis affinis* (Figure 17). These wasps parasitize leafcutter bee nests and are typically only found near them or raised from trap nests that were parasitized. These wasps are not commonly encountered, yet multiple adults were observed at Sand Point, indicating is a very healthy leafcutter bee (Megachilidae) fauna.

1.4.7 Other Notable Insects

Order Coleoptera: The Beetles

Certain beetle families visit flowers as adults and can move pollen around, fertilizing flowers. The family Cleridae (the checkered beetles) are common on the flowers of Asteraceae and Apiaceae. They were represented by *Trichodes nuttalli*, a common species across the Midwest. Ladybird beetles (family Coccinellidae) are voracious consumers of aphids and were observed on flowers during our surveys. Common species included *Harmonia axyridis* (the Asian ladybird beetle) and the large, native and variably colored, 15-spot ladybird beetle (*Anatis labiculata*). The 15-spot was common on both flowers and birch foliage as larvae and adults feeding on aphids. The parenthesis ladybird beetle (*Hippodamia parenthesis*: Figure 18) was occasionally seen, along with the introduced species *Hippodamia variegata* (the European variable ladybird beetle). The black tumbling flower beetle (*Mordella atrata*) was common on goldenrod

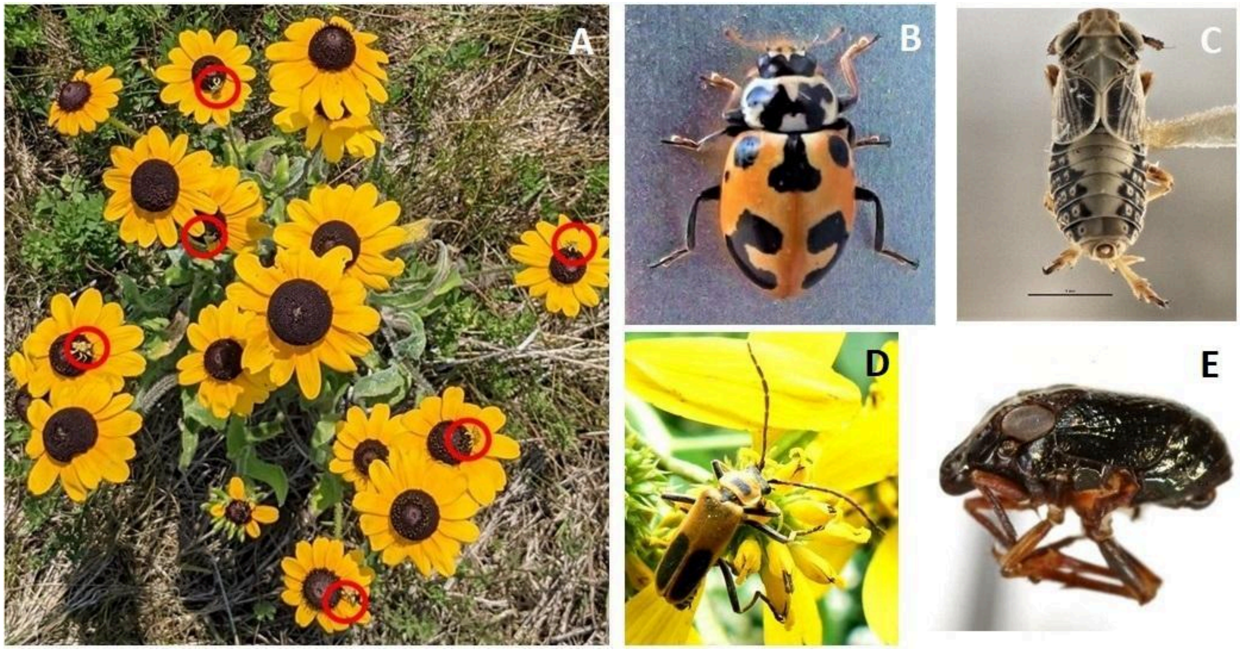

Figure 18. Additional insects recorded from KBIC Lands. A: No fewer than 6 ambush bugs (red circles) on a clump of black-eyed Susan (*Rudbeckia hirta*) at Sand Point in July, 2021 (photo by Jim Bess); B: parentheses ladybird beetle (via Carl Barentine), C: *Laccocera vittipennis* (via BOLD Systems); D: common soldier beetle (via Wikipedia) and E: *Bruchomorpha oculata* (via BugGuide – Mike Quinn).

(*Euthamia* and *Solidago* spp.) flowers throughout much of summer at both sites. *Chauliognathus pensylvanicus* (the common soldier beetle: Figure 18) was abundant on goldenrods and bonesets (*Eupatorium* spp.) at both sites during late summer. It feeds on pollen and is likely a significant pollinator.

Order Hemiptera: The True Bugs

In the Hemiptera, the alfalfa bug (*Adelphocoris lineolatus*) was very common at both sites given the presence of its favorite food, alfalfa. The ambush bug (family Phymatidae: *Phymata* sp. nr *fasciata*) was abundant at Sand Point in mid-summer (Figure 18), with lesser numbers observed at The Garden. This insect is a voracious predator of all flying insects and will attack large butterflies many times its size. Their abundance at Sand Point was amazing and indicates a very healthy overall insect population. Other Hemiptera observed include a variety of stink bugs (Pentatomidae) and shield bugs (Scutelleridae). Damsel bugs (family Nabidae) were also observed on foliage during our surveys. These are also predacious insects and feed on a variety of other species, providing biocontrol services. Giant waterbugs (family Belastomatidae: *Lethocerus americanus*) were regular occurrences in light trap samples. Hemiptera are not known to be effective pollinators, although Phymatidae likely move pollen around.

Order Homoptera: The Leafhoppers and Planthoppers

In the Homoptera, a couple of notable planthoppers (families Caliscelidae and Fulgoridae) showed up in a small sweepnet sample taken in one of the meadows at Sand Point in July. These were the spotted elephanthopper (*Bruchomorpa occulata*: Figure 18) and a panda planthopper (*Laccocera vittipennis*). *Bruchomorpha* are small, black, primarily wingless planthoppers that specialize on a variety of native bunchgrasses. *Bruchomorpha occulata* appears to be the most widespread and ecologically generalist of the group and I have taken it elsewhere in the UP on barrens remnants. *Laccocera vittipennis* (Figure 18) is a member of a western group of primarily flightless planthoppers and the only species with disjunct, isolated populations in the Upper Great Lakes and Northeast US (Discover Life, 2021). The Sand Point record is a first for the UP and Baraga Co.; the only previous specimens from Michigan are a small series from the tip of the lower peninsula (U of M Biological Station at Douglas Lake) from back in the 1920s and 1940s (Discover Life, 2021). Related species are reported to feed on grasses like *Elymus*, *Eragrostis* and *Mulenbergia*.

The introduced spittlebug *Lepyronia coleoptrata* is well-established at Sand Point and the author has observe them on the restoration site since 2010, along with the introduced leafhopper *Doratura stylata*. This last species was very common in the one sweepnet sample taken through the meadow area containing its foodplants, various grasses. This species is a pest on grasses and occurred in huge numbers (1,000s per sample) on replanted pastures containing this plant in southwest Montana (Bess et al., 2004). None of these insects are thought to be significant pollinators.

2.0 GOALS AND RECOMMENDATIONS FOR PROTECTING AND ENHANCING POLLINATORS ON KBIC LANDS

The following actions can be taken to greatly improve local lands as pollinator habitat and strengthen the local pollinator fauna:

1. Protect, enhance and encourage planting of pollinator-friendly vegetation throughout local communities and their buffer lands.
2. Develop "Pollinator Corridors" that link patches of high-quality, protected pollinator habitat.
3. Encourage "Best Practices" in local bee keeping.
4. Restrict pesticide use, especially in or near pollinator habitats.
5. Reduce mowing along roadsides and rights-of-way.

The ultimate goal of these actions is to ensure long-term stability in the local pollinator fauna, thereby ensuring that locally grown fruits, vegetables, herbs and wildflowers are bountiful for generations to come. It is also intended that these recommendations be implemented in a variety of ways that are aesthetically pleasing to the local inhabitants, involve on-going community participation and provide continuing opportunities for education and enlightenment.

2.1 BACKGROUND

Keweenaw Bay Indian Community Tribal Lands cover approximately 59,000 acres in Baraga County, Michigan and around the villages of Baraga and L'Anse along Keweenaw Bay of Lake Superior. Contained within these ancestral lands are a great variety of natural communities, along with areas recovering from resource extraction undertaken by European settlers and industrialists. At Sand Point in Baraga, a former brownfield site, restoration efforts on KBIC Lands over the past few decades have created a diverse array of habitats out of what were formerly highly degraded landscapes left over from historic copper mining activities. Newly created/restored habitats range from xeric sand dune uplands to mesic meadows, emergent wetlands and submerged aquatic beds.

The Debweyendan Indigenous Gardens in L'Anse occupy part of a large (~70 acre) old field complex surrounded by forest, providing a diverse array of habitats for pollinators. Recent restoration efforts have included planting a variety of fruiting trees and shrubs, plus flowering herbaceous species that further enhance its value for these critically important insects. The large acreage of open, relatively undisturbed herbaceous habitat at both sites is rare regionally and significant for pollinators and biodiversity in general. Protection and enhancement of this open habitat should be a key focus for managing pollinators in the area.

The following recommendations are aimed at attaining certain goals for protecting and enhancing habitat for pollinators and many other organisms, from birds to bats, humans, pine marten and moose. Pollinator plants can be incorporated into community plantings, edges of walking paths, ditches and roadsides to provide both habitat and aesthetic improvements.

Attractive plantings of flowers and grasses have been shown to be vital to increasing tourism, with Europeans having addressed this for some time and are having a large conference on the subject in 2023 (Paysalia, 2022; Cianga and Popuscue, 2003). Aesthetically pleasing landscaping containing flowering plants, shrubs and trees has also been shown to boost property value, sales and occupancy rates, while reducing stress and changing perceptions on how people view land and property (Texas A&M, 2022).

2.2 PROTECTING AND ENHANCING POLLINATOR-FRIENDLY HABITAT ON KBIC LANDS

To ensure the long-term health of domesticated and wild pollinators on KBIC Tribal Lands, high-quality areas of pollinator habitat need to be protected and managed with pollinators and native flora as a key focus. The protection and restoration of key pollinator areas is of great value and importance to KBIC, as it will provide a multitude of beneficial services for the community, from increased production of honey and beeswax to increased yields in fruits and vegetables. In addition to protecting existing bee habitats, efforts should be undertaken to plant additional areas of pollinator habitat throughout the local communities and surrounding Tribal Lands. Residents are encouraged to plant flower bots, planters or beds, and the plants don't necessarily have to be native to the region. Annuals like alyssum, cosmos, delphiniums, marigolds and zinnias are excellent pollinator species and can be mixed in with other perennials, like the native species listed in Appendix B.

Garden herbs like chamomile, basil, oregano, sage and thyme are also excellent pollinator plants when left to "bolt" or set flower. Flowering shrubs like crabapples, dogwoods and viburnums also attract pollinators, as do all locally-grown fruit trees and shrubs. Basswood is a fantastic nectar source and honey made from its flowers is very fine quality. This tree is also valuable for basketry and woodworking. By expanding the coverage and diversity of nectar and pollen sources across KBIC Lands, pollinators will be encouraged to expand their populations into residential areas, where they can provide pollinator services to local gardens and residences. Land-use changes and the continued warming of the climate will likely affect certain pollinators more negatively than others. Protecting, increasing and diversifying pollinator habitat across KBIC Lands will provide a buffer against these negative effects. A key part of this Goal is to ensure there is a steady, diverse supply of nectar and pollen sources throughout the growing season. Protected and enhanced habitats should cover a range of exposure, from full sun to shade and soil moisture levels, from xeric sand to saturated peat.

Many of the plants beneficial to pollinators and other insects are also important to humans for culinary, cultural, functional, medicinal or spiritual purposes. The native wildflowers, shrubs and trees listed in Appendix B are excellent upland resources for pollinators in the Keweenaw Region and are recommended for plantings wherever possible. Plants more adapted to constantly moist or wet soil are listed in Appendix B. Grasses, sedges and rushes are also integral to pollinators, from food for the caterpillars of butterflies and moths to resting and nesting sites for solitary bees, butterflies, flies and wasps. In upland areas, the species listed in Appendix A are important resources in our region and are recommended for planting. For wetter areas, a great variety of native grass, sedge and rush species are found in our local wetlands and are important to a variety of pollinators.

Ensuring the long-term retention of a diverse pollinator fauna requires the availability of a diverse assortment of nesting sites. The more pollinators you have living and reproducing on-site, the more of their offspring will view the site as their home territory and continue to reproduce there - if there are readily available nesting and floral resources. Suitable nesting materials vary among pollinators, with many bees preferring to nest in burrows in wood, plant stems or piles of dead leaves. Old rabbit nests are also often used by bumblebees. Some burrow under the edges of bunch grasses to build nests or burrow into the soil, making tunnels to provision with resources for their developing young. Areas of exposed soil are essential for nesting sites for these pollinators and many of the ground nesters will nest in dense groups, in areas of suitable soil conditions. Dry, gravelly-sandy soils are ideal for ground nesters and vegetation can be removed from, or soils placed in, areas to provide suitable nesting habitat. Examples of potential pollinator nesting structures are given in Figures 19-20.

Figure 19. Examples of potential pollinator nesting structures. From left: Log bench nesting site (photo via The Guardian), brush bundles (The Guardian), small formal bee nesting structure (via Kitchen Stewardship.com) and large nesting structure or "pollinator zoo" (via GAPP.org) on right.

Figure 20. Additional examples of potential pollinator nesting structures. From left: stump nest for mason/leafcutter bees (photo via Debra Dill); paper straw and reed nest construction (Ohio St. Univ.); drilling nesting tunnels in stump (Christine Bagot); log-bare soil nesting sites (Dreamland stock photo).

2.3 Developing "Pollinator Corridors" linking patches of high-quality, protected pollinator habitat

A variety of linear rights-of-way including interstate highways, railroads and walking paths pass through and connect the villages of Baraga and L'Anse. US 41 and the old Soo Line/Canadian National railroad pass through the Sand Point area and paved county roads link The Gardens to the Village of L'Anse. These would all be excellent areas to focus on creating or enhancing pollinator habitat. Providing connectivity between these pollinator areas will be crucial to ensuring the long-term diversity and robustness of the local pollinator fauna. Enhancing and restoring habitats for pollinators within and around the villages of Baraga and L'Anse will be necessary to attaining this goal. These efforts should aim to connect the faunas of isolated, high-quality pollinator sites like The Gardens and Sand Point.

The waterfront and US-41 corridor in Baraga represent an excellent opportunity for incorporating pollinator-friendly habitats into efforts to provide access, increase tourism and move foot and bike traffic safely through town. The recently constructed walking/biking path along the waterfront on the north side of town and adjacent undeveloped lands present excellent opportunities for planting attractive pollinator habitat. Such plantings could be duplicated by businesses, landholders and the village throughout town south to the State Park. These plantings could be continued along the US 41 right-of-way around Keweenaw Bay and then continue into L'Anse. This would provide a nearly unbroken corridor of pollinator habitat around the southern third of the Bay. Plantings could be continued into and through L'Anse and out towards the hospital and even out Pequamming Rd. and Main Street towards Pequamming and Skanee. Plantings could also be continued north of Baraga along US 41 to Assinins and beyond. Such projects will require cooperation between KBIC, local landowners, businesses, the USDOT and MDOT. Limiting mowing and herbicide application in these areas would be integral to their success.

2.4 MAINTAINING BEST PRACTICES IN LOCAL BEE KEEPING

Given the importance of honeybees to local economies (no fewer than 2 commercial apiaries operate nearby), it is essential that local bee colonies are kept in the healthiest condition possible (Best Practices). Much of Best Practices for Beekeeping centers around providing optimal habitat for the bees throughout the year. Honeybees (like many other pollinators) are active all growing season, so require nectar and pollen sources from early May through September in our region. This means a diverse array of flowering plants must occur within their foraging area to adequately nourish the hive. If there are too few nectar sources, the bees won't have enough honey stored to get them through the winter and the colony starves. Reduced nectar sources can also stress bees, making them weak and susceptible to parasites and diseases. Beekeepers need to also ensure that their bees are not being exposed to pesticides while foraging. Communicating with local landowners and municipalities is key to ensuring minimal pesticide usage is occurring in areas of pollinator habitat.

Best Practices also requires that beekeepers tend to their hives regularly, inspecting them for damage, parasites or infections in the honeycomb or bees. Varroa mites () are an extreme problem with honeybees and are the prime culprit in the recent honeybee colony collapse disorder that has swept through North American bee colonies for the past 20 years. Inspecting for these mites should be a regular occurrence among beekeepers. Waxworms and a variety of other pathogens, predators and parasites can attack honeybee colonies, in hives and the wild, so regular inspection is necessary. Michigan State University: Extension has a variety of resources for beekeepers (MSU, 2022a). There are also rules and regulations that need to be followed for beekeeping in Michigan (MSU, 2022b).

In general, the following should be incorporated into a local Beekeeping Best Practices Program:

- Maximize beehive health and hive pest/disease control.

- Identify the types of local pesticide use (e.g., agricultural, residential, public health, public recreational, landscape, etc.) and encourage minimization or cessation of pesticide application in pollinator-occupied areas.
- Maintain and increase acreage of, and improving access to, pollinator-friendly foraging and nesting habitat.
- Maximize the quality and quantity of habitat for domesticated and wild pollinators.
- Minimize stressors to domesticated and wild pollinators.
- Minimize stressors to native habitats (i.e. mowing and spraying)
- Maximize domesticated beehive health and survival.
- Provide Pollinator Outreach (Information on pollinator-friendly practices).

2.5 MINIMIZING PESTICIDE USAGE ON KBIC LANDS

The overzealous use of pesticides represents one of the primary threats to pollinators and other insects and this includes both insecticides and herbicides. Efforts to control agricultural pest insects have led to a dizzying array of noxious chemicals being applied to our land, air and water. Many of these insecticidal chemicals are also hazardous or deadly to humans, our pets and various wildlife. Most recently, neonicotinoid insecticides have been developed and these have been shown to be especially harmful to pollinators. In addition to being lethal in high doses, these chemicals also have deleterious effects at very low levels and have been shown to affect the behavior of bees, leading to nesting colony collapse in honeybees and bumblebees. Herbicide application along roadsides, powerline rights-of-way and field edges kills nectar sources and nesting habitats for bees, reducing the amount of local habitat for them.

Therefore, it is recommended that pesticide usage be limited to “most needed” cases, i.e. those where insects are causing local losses of valuable plants, shrubs or trees. Education materials should be provided to residents showing the virtues of pollinators and many other insects. This education effort should also provide recommendations on protecting them while still maintaining vibrant and attractive properties. Neonicotinoid herbicides should be avoided, and citizens educated on their effects on beneficial insects. Part of this should be ensuring that nursery stock and seeds that are brought into the community have not been treated with these chemicals. Most retailers have begun to end the use of these pesticides in nursery stock, but this is not universal nor required by law. Customers should always ask vendors about these chemicals and whether plants or seeds have been treated. Herbicide use should be limited to controlling invasive species or clearing areas to be planted with native vegetation.

2.6 REDUCING MOWING ON KBIC LANDS

the trails and roadsides within and around Sand Point could be used to connect the pollinator fauna there with Baraga and the local landscape. The edges of US-41 and the north and south access roads currently provide critical habitat for pollinators, and this should be protected and enhanced through additional plantings and cessation of mowing during the growing season wherever possible. The mowed lawn around The Pines Convenience Center, Tribal Police Station and the local cemetery could be planted to native wildflowers and grasses to attract pollinators. Habitat could be expanded northwards along roadsides and local multiple-use trail systems. To the south, the corridors could connect with the Baraga walking/biking path along US-41 and Keweenaw Bay, and even continue around the Bay through L'Anse.

As mentioned above, the roadsides at Sand Point provide pollinator habitat and serve as dispersal corridors for these and other organisms. Mowing during the growing season, while the plants are flowering, is very detrimental to nesting pollinators. Whenever possible, mowing along the roadsides and trails should be delayed until fall (September-October) whenever possible. In areas that require mowing during the growing season, a single, narrow mowed strip along the roadside is preferred over a broadly mowed right-of-way. Michigan Department of Transportation (MDOT) could also be contacted about limiting mowing along US-41, if necessary.

we recommend that, whenever possible, growing season mowing should be kept to a minimum, especial on rural roads adjacent to natural areas. We understand there are safety concerns regarding visibility, etc., but trees and shrubs can be maintained through fall or winter mowing, reducing the negative effects on local wildlife. We also recommend (whenever possible) replanting roadsides and rights of way with native grasses, sedges and wildflowers to provide habitat for pollinators, insects and the wildlife that feed on them. Iowa has replantedmuch of the margin of US-80 to tallgrass prairie vegetation and there is currently a multi-state effort to plant a “monarch corridor” of milkweed and wildflowers along US-35 from Minnesota to Texas for the monarch butterfly (Danaus plexippus). Other states along this route are currently able to apply for funds to undertake similar effort of their own and this program (along with others) could be used to create habitat for Papaipema eryngii, the monarch and native pollinators.

2.7 RECOMMENDATIONS FOR CONTINUED POLLINATOR SURVEYING

While introductory pollinator surveys found a diverse pollinator fauna with several rare species on KBIC Lands, it is likely that many more remain to be discovered, particularly bees and moths. If there is interest and funding is available, continued pollinator surveys are strongly recommended through at least another season. It typically takes 2-3 years of continued sampling to discover the bulk of a local insect fauna, with rare species sometimes taking several years to be “discovered”. Information gathered during additional surveys could aid in future land management decisions for each of the sites and KBIC Lands in general.

One area that should be investigated further is the presence of the “wild rice worm” (*Apamea apamiformis*) at Sand Point. While this insect has been implicated in commercial wild rice losses in parts of northern Minnesota and Ontario, it appears to be very rare elsewhere, with few records anywhere in the past 45 years. The collection at Sand Point represents the first for the UP and only the second from the state in the past 50 years. The other population occurs in Cass Co., at a wetland (fen) with no wild rice. Many other *Apamea* species occur within the range of wild rice. Most have little known about their life histories, other than all appear to feed on grasses, particularly native wetland grasses like *Glyceria, Spartina* and *Zizania*. It is unknown if these other *Apamea* species also feed on wild rice but is entirely possible.

Given the presence of wild rice beds at Sand Point, it should be determined if this moth is feeding on the wild rice and to what extent. It should also be determined if other *Apamea* species are also feeding on the wild rice. These moths are highly effective pollinators of many plants, including native orchids and various garden plants. Adults and larvae will need to be collected to make proper species-level determinations. Information from such a study would be very helpful in determining how to best maintain the Manoomin beds at Sand Point and elsewhere on KBIC Lands. Such information would also be useful to other Manoomin growers in the region.

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