CITY OF Ames

Caring People ◆ Quality Programs ◆ Exceptional Service

MEMO

Date: May 17, 2023

To: Mayor and City Council

Cc: Steve Schainker, City Manager
John Joiner, Director of Public Works

From: Tracy L. W. Peterson, Municipal Engineer

Subject: City of Ames Pollinator-Friendly Community Plan 2023-2032

Worldwide, there is scientific evidence demonstrating that pollinators and other insects are declining. Our world needs pollinators, as our food systems and environment depend on these animals. Growing evidence points towards five main drivers of pollinator decline: 1) loss of habitat, 2) pesticides and other chemical pollutants, 3) pathogens, 4) climate change, and 5) introduced species.

Even the small action of planting native plants can positively impact local biodiversity and create a more resilient environment. In Iowa, this resilience can also be demonstrated through incorporating deep-rooted native vegetation on public property. Native plants not only provide habitat for pollinators and other wildlife; they also improve water quality, increase streambank stability, and reduce flooding.

Throughout the past nineteen years of working at the City of Ames, I have heard many residents express interest in native plants for their yards and publicly owned land. As part of the City of Ames Smart Watersheds Program, the City has given away thousands of native plants, native seed packets, and tree seedlings to the public at community outreach events. More recently, City staff has worked with both Ames High School classes and The Community Academy to grow native grasses and flowers to distribute to residents and to plant within the city's green infrastructure. The City of Ames Smart Watersheds Program offers cost share rebates for: native vegetation, rain gardens, native trees, soil quality restoration, rain barrels, and composters.

The Ames Pollinator-Friendly 10-Year Community Plan was created to empower the community of Ames, Iowa, to do its part in slowing insect pollinator decline in Iowa. Iowa has over 2,500 native pollinator species (nearly 400 bees, 110 reproducing butterflies, and 2,000 species of moths), including the federally endangered rusty-patched bumble bee, found right here in the City of Ames.

A team of diverse members joined together to create the Ames Pollinator-Friendly Community Task Force including the following:

Dr. Lori Biederman – Iowa State University, Friends of Brookside Park	**Cory Geffre** – Mary Greeley Medical Center
Dr. Gina McAndrews – Century 21	**Dr. Tyler Harms** – Iowa Young Birders
Dr. Paul Domoto – Friends of Ada Hayden Heritage Park	**Dr. John Pleasants** – Iowa State University
Stephanie Fox – Friends of Ada Hayden Heritage Park	**Pat Sauer** – Iowa Storm Water Education Partnership
Nate Schlorholtz – Bolton & Menk Inc.	**Ashley Geesman** – HDR, Inc.
Liz Calhoun – City of Ames	**Angie Kolz** – WHKS & Co.
Jake Moore – City of Ames	**Kyle Jacobsen** – City of Ames
Jessica Butters – Prairie Rivers of Iowa RC&D	**Penny Brown Huber** – Prairie Rivers of Iowa RC&D
Tracy Peterson – City of Ames	

The plan uses four pathways (education, policy, research, and partnerships) to leverage the excitement and interest that currently surrounds pollinators to recruit more people, businesses, and other entities to address pollinator decline. Our office has already been contacted this year by two Ames businesses who are interested in converting traditionally mowed lawn to native vegetation/pollinator garden and we haven't even published this plan yet!

The plan is comprised of four main goals. Under each goal is one or several "Strategies" needed to obtain that goal. Then, under each strategy, we outline "Action" items. These are specific actions that need to be taken in order to work towards each strategy. Some action items contain additional "Implementation Steps", which are more detailed steps that the task force created to help guide large or complex action items. The action items are organized by whether they pertain to Education, Policy, Research, or Partnerships. This categorization will be helpful for current and future task force members when organizing future goals and determining responsibilities.

Residents are encouraged to join the Ames Pollinator Planning Committee that will be implementing this 10-year plan starting in 2023. If you or someone you know is interested, please contact Penny Brown Huber (pbrownhuber@prrcd.org; 515-232-0048) at Prairie Rivers of Iowa.

The City of Ames Pollinator-Friendly Community Plan, can be located on the City of Ames website at: https://www.cityofames.org/government/departments-divisions-i-z/public-works/stormwater-program/bird-friendly-community

The City of Ames Pollinator-Friendly Community Plan 2023-2032

CITY OF ames

PRAIRIE RIVERS of Iowa

Acknowledgments

We would like to express our sincere thanks to all of the members of the Ames Pollinator-Friendly Community Task Force. Thank you for dedicating your time to cultivate ideas and create a plan to address pollinator decline in our community and the world at large.

We would also like to thank the City of Ames and Homewood Golf Course staffs for helping to host our meetings and for providing technical assistance.

City of Ames Pollinator-Friendly Community Task Force

Tracy Peterson – City of Ames
Liz Calhoun – City of Ames
Kyle Jacobsen – City of Ames
Jake Moore – City of Ames
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The City of Ames Pollinator-Friendly Community Plan 2023 - 2032

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Graphic Designer: Mike Kellner
Photography: Jessica Butters, Mike Kellner, Prairie Rivers of Iowa Staff, David Stein, USFWS, CC BY-NC-SA 4.0

WORLDWIDE, THERE IS SCIENTIFIC EVIDENCE DEMONSTRATING THAT POLLINATORS AND OTHER INSECTS ARE DECLINING.

This could have detrimental impacts on our food crops, animal wildlife, plant survival, and more. One of the main drivers of pollinator decline is habitat loss, mostly caused by the expansion of farmland and urbanization. Another major concern for pollinators and humans is climate change. Recently, the Midwest witnessed increases in extreme weather events such as droughts, devastating flooding, and a derecho. To address these issues, it is essential that our urban areas start improving the current state of their native pollinators and the surrounding natural environment.

Residents, businesses, and government agencies can take action, big or small, to effectively provide pollinator habitat, improve water quality, enhance soil health, and grow healthier foods. For instance, even small, residential yards growing native plants can support wildlife and reduce stormwater runoff. The small action of planting native plants can positively impact local biodiversity and create a more resilient environment.

In Iowa, this resilience can also be demonstrated through incorporating deep-rooted native vegetation on public property. Native plants not only provide habitat for pollinators and other wildlife; they can also improve water quality, increase streambank stability, and reduce flooding. For example, the community of Dubuque, Iowa, experienced an intense, 13-inch rainfall. While traditional waterways would have been marred, their waterway planted with native vegetation experienced no damage as it safely conveyed this extreme amount of stormwater. Other communities have reduced runoff and flooding through converting typical compacted lawn area or agricultural fields into native prairie vegetation. These conversions create multi-faceted environmental benefits for the community, pollinators, and environment.

Throughout the past nineteen years of working at the City of Ames, I have heard many residents express interest in native plants for their yards and publicly-owned land. As part of the City of Ames Smart Watersheds Program, the city has given away thousands of native plants, native seed packets, and tree seedlings to the public at community outreach events. These plants are always well received and have been planted throughout the community. More recently, city staff has worked with both Ames High School classes and The Community Academy to grow native grasses and flowers to distribute to residents and to plant within the city's green infrastructure. There is an exciting movement in our city towards caring for our natural environment and the species that depend upon it.

This interest in supporting our natural environment in Ames, along with being a sustained Bird-Friendly Community in Iowa, has led to the creation of this Task Force and the development of the Ames Pollinator-Friendly Community Plan. The plan outlines steps to take in the next 10 years to create a more pollinator-friendly city. The Task Force members represent independent thinkers with a variety of experiences to create opportunities for collaboration across fields and organizations. I personally learned much from Task Force members during the creation of this plan. As ideas move forward and are implemented in our community, I am excited to share it with our residents.

Residents are encouraged to join the Ames Pollinator Planning Committee that will be implementing this 10-year plan starting in 2023. If you or someone you know is interested, please contact Penny Brown Huber (pbrownhuber@prrcd.org; 515-232-0048) at Prairie Rivers of Iowa or myself at the information below. There is a lot of exciting work to be done through the diverse perspectives and passions of our residents.

As far as we know, this is the first 10-year pollinator-friendly plan created for a city in the United States. I am grateful for all those who contributed to its creation. Thank you.

Respectfully,

Tracy L.W. Peterson, P.E.
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Public Works Department
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EXECUTIVE SUMMARY

Our world needs pollinators, which are a key group of animals that our food systems and environment depend on. They pollinate over one-third of our global food crops[1] and 87.5% of our world's plant species[2]. Beyond their relationship with plants, insect pollinators are an essential food source for birds and many other animals, forming an important link between plants and animals in our natural ecosystems.

Insect pollinator numbers are declining, in some cases at alarming rates. Growing evidence points towards five main drivers of pollinator decline: 1) loss of habitat, 2) pesticides and other chemical pollutants, 3) pathogens, 4) climate change, and 5) introduced species[3,4]. This decline comes at a cost, with lower pollinator population numbers already linked to declines in bird populations[5,6], and pollinator-dependent plant species[7]. Additionally, human health could be negatively affected if pollinator loss continues, as many nutritious crops rely on insect pollination[8,9].

The Ames Pollinator-Friendly 10-Year Community Plan was created to empower the community of Ames, Iowa, to do its part in slowing insect pollinator decline in Iowa. Urban communities, such as Ames, have the capability to support a diverse community of native pollinators[10]. There is an estimated 40 million acres of urban lawn and turf in the United States[11], from private yards to areas largely unused, such as right-of-ways. As an urban community, Ames has the opportunity to convert its under-used turf areas into environmentally-conscious pollinator habitat. Planting diverse vegetation not only supports pollinators; it can also have a positive impact on residents' mental health[12], and therefore enhance their quality of life.

The City of Ames is blessed by its location in Central Iowa, just north of the City of Des Moines and near many rural and State parks. Iowa has over 2,500 native pollinator species (nearly 400 bees, 110 reproducing butterflies, and 2,000 species of moths), including the federally endangered rusty-patched bumble bee, found right here in the City of Ames.

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1 Klein et al., "Importance of Pollinators in Changing Landscapes for World Crops."
2 Ollerton, Winfree, and Tarrant, "How Many Flowering Plants Are Pollinated by Animals?"
3 Wagner et al., "Insect Decline in the Anthropocene."
4 Potts et al., "Global Pollinator Declines."
5 Hallmann et al., "Declines in Insectivorous Birds Are Associated with High Neonicotinoid Concentrations."
6 Tallamy and Shriver, "Are Declines in Insects and Insectivorous Birds Related?"
7 Biesmeijer et al., "Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands."
8 Ellis, Myers, and Ricketts, "Do Pollinators Contribute to Nutritional Health?"
9 Smith et al., "Pollinator Deficits, Food Consumption, and Consequences for Human Health."
10 Fetridge, Ascher, and Langellotto, "The Bee Fauna of Residential Gardens in a Suburb of New York City."
11 Milesi et al., "Mapping and Modeling the Biogeochemical Cycling of Turf Grasses in the United States."
12 Methorst et al., "Species Richness Is Positively Related to Mental Health – A Study for Germany | Elsevier Enhanced Reader."

EXECUTIVE SUMMARY continued....

Our plan builds on these strengths and leverages our active community to address pollinator decline. To accomplish this, we outline a step-by-step plan that utilizes four pathways: education, policy, research and partnerships.

Through these four pathways, our plan will: 1) educate the public about Iowa's pollinators and their current plight, 2) create and build on city policy that supports pollinator conservation, 3) research Ames' current pollinator population and community member knowledge base and attitudes, and 4) create and strengthen partnerships between the City of Ames, conservation and non-profit organizations, Iowa State University, and others to use all resources to their fullest potential in support of pollinators. These four pathways of our plan address the main drivers of pollinator decline by slowing habitat loss through habitat planting, addressing pesticide use on public and private lands, emphasizing the importance of native pollinators, highlighting the need for native plants, and promoting sustainable yard and land management practices.

Specifically, our plan uses these four pathways (education, policy, research, and partnerships) to leverage the excitement and interest that currently surrounds pollinators to recruit more people, businesses, and other entities to our cause. Educating the public, along with city staff and officials, will allow us to create more pollinator habitat, lower pesticide use, encourage using native plants over nonnative plants, and champion sustainable practices to combat climate change. By creating or enhancing current City policies, we can plant native habitat on public land, lower City pesticide use, and replace nonnative plants that are normally planted with native, pollinator-supportive plants. By conducting research, we address the lack of data on native pollinators. The City of Ames is home to Iowa State University, an R1 research institution that will be an excellent partner for data collection and research. Lastly, creating and strengthening partnerships will enable our community to effectively leverage available knowledge and resources to successfully carry out our vision.

It is our vision for the City of Ames to develop and sustain beautiful and healthy native habitat that will not only serve pollinators and other wildlife, but also serve Ames residents and all who visit. Ames is a special place – besides being a home for the rusty-patched bumble bee, it is also a university town. Iowa State University provides not only expertise and an active student body, it also draws a constant flow of visitors to our city. This gives us the unique ability to serve as an example for other communities and provide a framework to start their own pollinator-friendly communities. Pollinator decline is indicative of an unhealthy and fragmented world. By addressing pollinator decline, we will create healthier communities and enhance the quality of life, for both wildlife and people.

PLAN STRUCTURE

Our plan is comprised of four main goals.

Under each goal is one or several “Strategies” needed to obtain that goal. Then, under each strategy, we outline “Action” items. These are specific actions that need to be taken in order to work towards each strategy. Some action items contain additional “Implementation Steps”, which are more detailed steps that the task force created to help guide large or complex action items. The action items are organized by whether they pertain to Education, Policy, Research, or Partnerships. This categorization will be helpful for current and future task force members when organizing future goals and determining responsibilities.

Additionally, this 10-year plan ends with a list of Iowa’s at-risk pollinator species (this list is the most current list available from the Iowa Department of Natural Resources (DNR) and US Fish and Wildlife Service (USFWS) websites) and a table showing the City of Ames’ “At Risk Pollinators”, developed by this task force. This table is meant to serve as a resource to help the task force prioritize conservation efforts for pollinators listed by the state or federal governments (and bumble bees listed by the International Union for Conservation of Nature (IUCN)). The species included in the table are listed butterflies and bumble bees that have been seen in Story County or adjacent counties in the last 10 years (with the exception of the Dakota and Poweshiek skippers, and the Baltimore checkerspot), and whose host plants are native to Story County or adjacent counties. Conservation efforts should also be taken for common pollinators as well, as they are equally important and readily visible to the public.

While all native insects are, or course, immeasurably important to maintaining the world as we know it, pollinators fill a special niche. They are not only a vital connection between plants and animals, but they are also one of the few insect groups that are becoming visible to and beloved by the public. Our focus on pollinators, both common and rare, stable or declining, provides a gateway for the public to start caring about other insects, native plants, and, eventually, the natural environment as a whole.

DEFINITIONS

Pollinator – an animal that transfers pollen between flowers, allowing for seed development.

- In this plan we are most often referring to insect pollinators.

Native – a species that originated in and is adapted to its current environment.

- Planting plants that are native to an area provides high-quality resources, such as nectar and nesting sites, for pollinators.

Non-native – a species that is not originally from a particular place.

- Non-native plants, in general, either do not provide resources or provide lower-quality resources for pollinators compared to native plants.

Habitat – the characteristics of an area, including resources and physical features, in which a particular species lives.

- Pollinators need habitat that provides nesting, overwintering, and food resources. Many nest in the soil and need flowers for nectar and pollen.

Foraging plant – a plant that provides food for wildlife.

- Foraging plants for pollinators include plants that provide pollen and nectar.

Host plant – a plant that provides vital shelter, breeding sites, or food as a part of an animal's life cycle.

- Milkweed is the host plant of monarch butterflies; without it monarch butterflies cannot survive. Monarch caterpillars only feed on milkweed, and adult monarchs lay their eggs on milkweed alone.

Biological community – a group of species that interact and influence one another in a given area.

- For example, a biological community would have populations of butterflies, flowers, and birds (to name a few). The flowers are visited by butterflies, butterfly caterpillars are eaten by birds, and birds also eat seeds from the flowers. Each species interacts with other species in the area.

DEFINITIONS continued....

Ecosystem – an area where living organisms interact not only with each other, but with the abiotic environment as well (including nutrients, water, climate, etc.).

- Tallgrass prairie is an example of an ecosystem. It has tall plants, pollinators, other insects, mammals, deep soil, and a temperate climate all interacting to create what we call a "prairie".

Ecologically-beneficial green space – some urban spaces are called "vegetated" or "green space", and serve a purpose, such as recreation. An ecologically-beneficial green space extends this concept by providing multiple benefits to organisms, the environment, and people.

- For example, a native plant garden on a steep slope would support native pollinators and mitigate runoff, which helps wildlife and improves water quality at the same time. Additionally, the sight of wildflowers, butterflies, and other wildlife beautifies the area, in turn benefiting the people visiting the area.

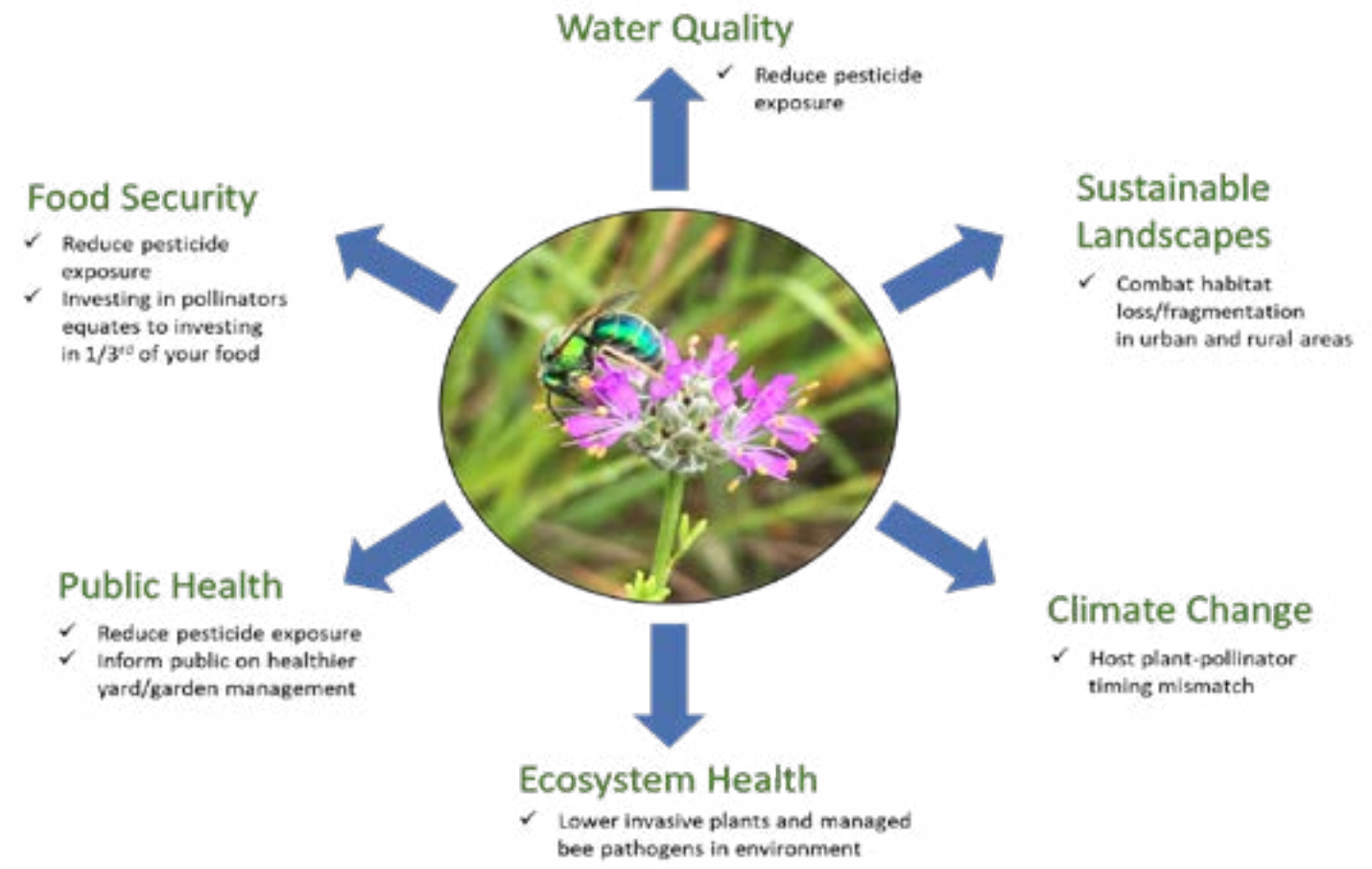
Neonicotinoid – a relatively new group of insecticides that are related to the chemical nicotine. They attack the nervous systems of insects, and may impact other organisms as well.

Resident – a person living in Ames or its urban-fringe area.

IUCN – the International Union for Conservation of Nature; a research-based nonprofit organization.

Imperiled – a word used to describe a group of or species of pollinators whose populations appear to be in decline. The group or species in question is not necessarily officially listed by federal or state governments.

WHY FOCUS ON POLLINATORS?



Pollinators are important indicators of environmental health due to their dependence on a diverse and healthy ecosystem. By focusing our 10-year plan on mitigating pollinator decline, we are providing a framework to create a healthier community, for both wildlife and for people. Actions that improve pollinator populations have direct impacts on overall sustainability.

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The City of Ames
Pollinator-Friendly Community Plan
2023-2032

Vision Statement

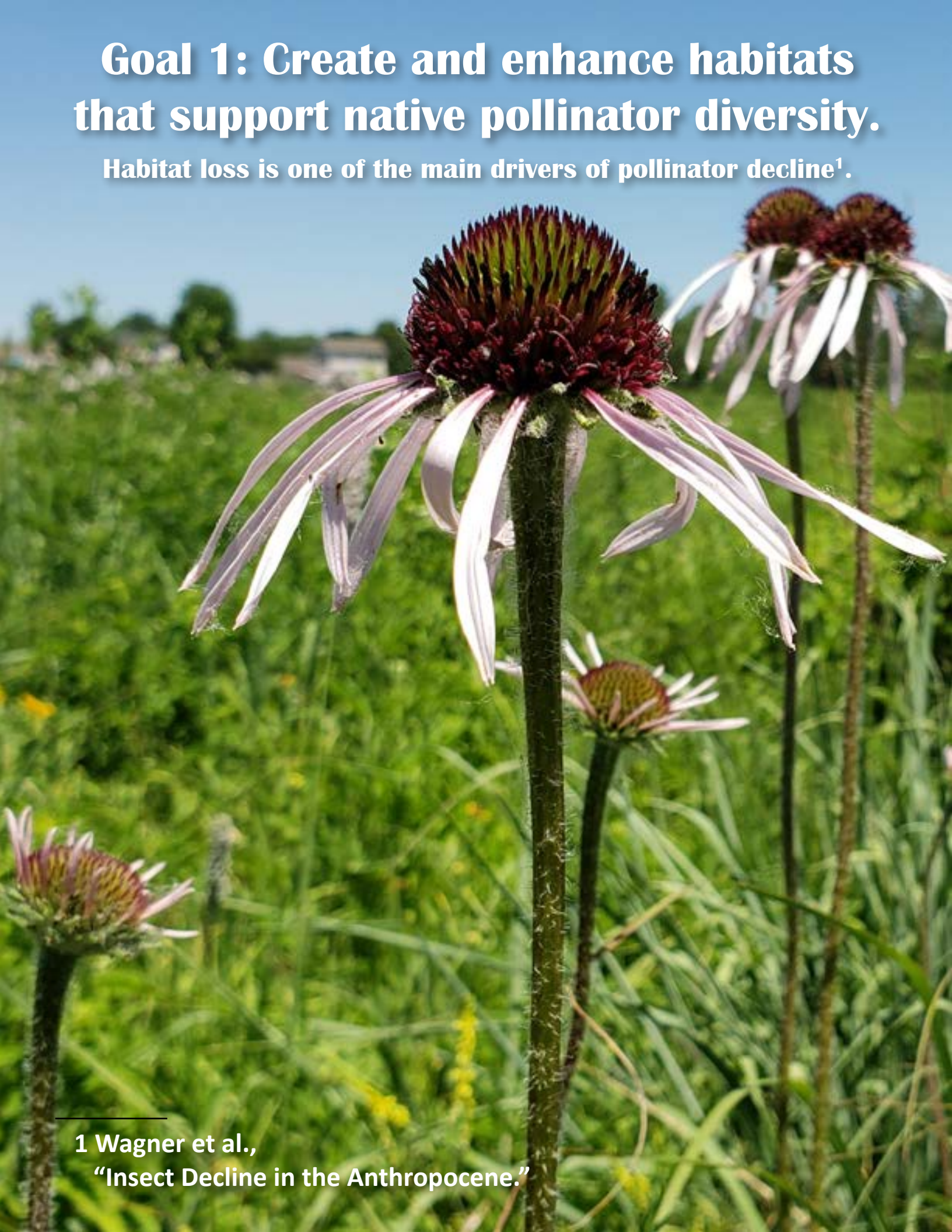
To become a leader in developing and sustaining pollinator habitat that will enrich the quality of life for the human and biological communities of Ames.

Global Impact Statement

This framework will support the pollinator community to address food insecurity, ecological health, offset the impacts of climate change, and will serve as an example for other cities around the world.

Goal 1: Create and enhance habitats that support native pollinator diversity.

Habitat loss is one of the main drivers of pollinator decline[1].



1 Wagner et al.,
"Insect Decline in the Anthropocene."

Goal 1: Create and enhance habitats that support native pollinator diversity.

Strategy 1: Increase the number of households possessing native pollinator habitat by fifty percent.

Education

Action 1: Over 10 years, the number of Ames households able to identify five native or nonnative plants in their yard will increase by fifty percent.

Implementation Steps

- Survey City of Ames residents to establish the public's baseline knowledge of native plants and insects.
- Distribute information about native plants, pollinator decline, and examples of native landscaping to: homeowner associations (HOAs), neighborhood associations, new homeowners, and neighborhoods located in areas of high concrete and low green space.
- Help HOAs tailor their covenants to allow native pollinator habitats, e.g. sprawling pollinator gardens, leaf layers, dandelions, etc.
- Present a series of EcoChats on pollinator-friendly yard maintenance and practices annually.
- Encourage edible landscapes and educate the public about the impact of pollinators on food security.
- Educate households on lowering light pollution to lower harmful impacts on nocturnal pollinators and other insects.

Action 2: Engage and educate landscape and plant material suppliers to sell Iowa-native plants, especially those that are most beneficial to pollinators.

Implementation Steps

- Distribute list of native plant suppliers to Ames households.
- Work with native plant suppliers to promote the Ames Smart Watersheds Cost Share Rebate programs to Ames residents.

Action 3: Present annually to landowners owning one acre or more (e.g., HOA/rental properties, churches, schools, Iowa State University (ISU), railways, or mobile home parks) explaining pollinator importance and their decline.

Implementation Steps

- Distribute information outlining clear steps to successful establishment and management of native plants for areas that are one acre or larger.
- Coordinate native landscape professionals with Ames businesses and landowners owning one acre of land or more, including ISU, to plant native plants.
- Review the Ames Smart Watershed Cost Share Rebate programs for considering HOAs and landowners owning over one acre of land.

Action 4: Offer signage/recognition for pollinator or habitat in private yards or business landscaping.

Action 5: Distribute a simple, step-by-step guide describing the growing process, timeline, and importance of maintaining pollinator habitat.

Implementation Steps

- Guide will initially be for properties smaller than one acre, including apartment patios and balconies.
- Guide will eventually include considerations when planting in right-of-ways, where visibility must be maintained for vehicles.

Action 6: Distribute welcome guides to new homeowners about the City of Ames' pollinator goals and native landscape maintenance, possibly through real estate agents or HOAs.

Policy

Action 1: Create a rebate for invasive species control on private properties.

Research

Action 1: Quantify the number of households, commercial property, and ISU property currently possessing pollinator gardens/habitat.

Action 2: Seek funding for at least three new incentives to add pollinator plants to private and rental properties.

Partnerships

Action 1: Engage with ISU leadership, facilities, faculty, and students to identify current pollinator habitat and search for areas to increase habitat on ISU properties.

Action 2: Engage annually with the resident-driven Ames Climate Action Team and (to-be-hired) City of Ames Sustainability Coordinator during implementation of the Ames Climate Action Plan.

Strategy 2: Double the current amount of native pollinator habitat on public properties in Ames corporate limits and urban fringe over the next 10 years.

Education

Action 1: Beginning in 2023, identify and assist in annual training opportunities for City of Ames staff about pollinator habitat and related landscape management and protection practices.

Action 2: Place educational signage near City native plantings to educate the public about pollinators and their habitat requirements.

Implementation Steps

- Post signage at City native plantings explaining the difference between traditional turf lawns and ecologically-beneficial green space.
- Connect pollinator conservation with water quality, stormwater runoff, and other environmental issues.
- Install brochure holders or QR codes next to plantings that contain bite-sized information on how to support pollinators at home, City rebate programs, and a few native plant species to plant.
- Include both easy and advanced examples of how to support pollinators at home (e.g., from a few potted native plants to yard conversions).
- Post signage at new City plantings explaining the timeline for growing native habitat.

Action 3: Plant educational pollinator plots near community gardens.

Implementation Steps

- Recruit resident groups to establish native pollinator plots near community gardens.
- Create and post educational signage about the benefits of native pollinators, other beneficial insects, and pollinator-friendly gardening practices, such as lowering the broad application of insecticides.

Action 4: Enhance existing educational initiatives for homeowners to start replacing turf to include pollinator habitat.

Action 5: Review city landscape and park management practices to meet sustainability and pollinator support goals.

Policy

Action 1: Review City of Ames policies annually to determine opportunities for creating new policies that would add pollinator-supportive plants to public land.

Action 2: Evaluate Capital Improvement Plan projects and other city projects for inclusion of native pollinator habitat.

Implementation Steps

- Utilize marginal land: closed landfills, areas of high erosion, abandoned lots, etc.
- Create a shortlist of qualified native landscape professionals to be contracted for city plantings, burns, and maintenance.
- Create and find small business opportunities for native landscape management.
- Secure funding, staff, and equipment for the City to enhance city-owned park management.
- Create a list of short-stature plants that can be utilized in right-of-ways to maintain required sight distance for City property.
- Create a list of shade tolerant native plants to utilize in City woodlands and stream restoration projects.

Research

Action 1: Determine baseline amount of natural habitat on public land in Ames corporate limits and urban fringe.

Partnerships

Action 1: Partner with the Department of Transportation (DOT) and other government agencies to identify marginal land or right-of-ways that can be planted with native pollinator habitat.

Strategy 3: Identify and connect city and public green spaces to create pollinator habitat corridors.

Policy

Action 1: Based on research findings, develop policies to increase the connectivity of current and potential pollinator habitats by 50% over the course of 10 years.

Implementation Steps

• Develop planting guidelines for public lands located in key connecting areas for pollinator habitat. For example, city-owned green space located between a creek and a prairie planting would be an ideal place to plant native pollinator habitat.

Research

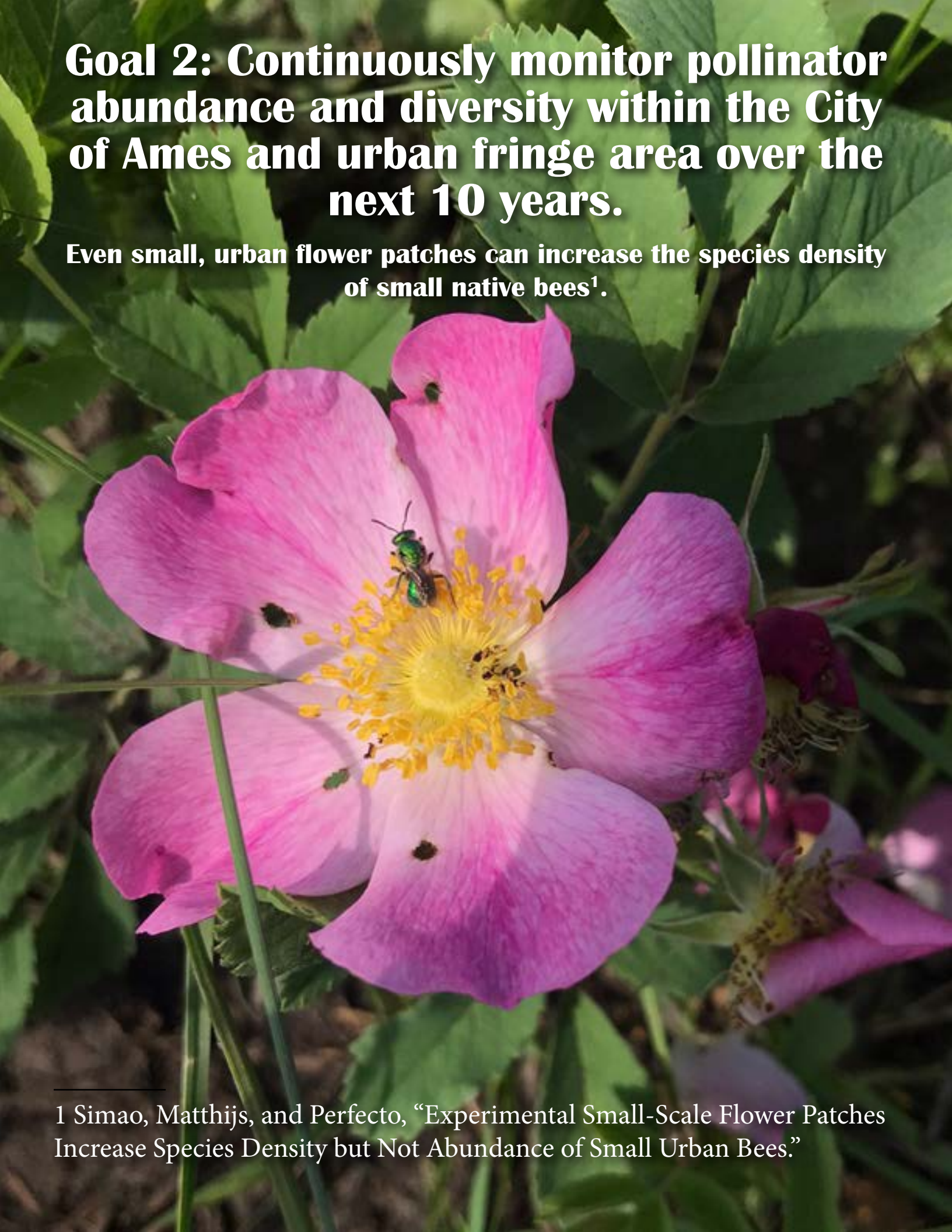
Action 1: Create and regularly update maps within the City of Ames and urban fringe to identify underutilized green spaces, landowners owning one acre or more (e.g., churches, schools), and potential areas for pollinator habitat and habitat corridors.

Partnerships

Action 1: Engage with Iowa State University, Story County Conservation, HabiTally, Plant. Grow.Fly, Iowa Natural Heritage Foundation (INHF), the DOT, the United States Department of Agriculture (USDA), and other organizations to implement and map pollinator habitat in Ames.

Goal 2: Continuously monitor pollinator abundance and diversity within the City of Ames and urban fringe area over the next 10 years.

Even small, urban flower patches can increase the species density of small native bees[1].



1 Simao, Matthijs, and Perfecto, "Experimental Small-Scale Flower Patches Increase Species Density but Not Abundance of Small Urban Bees."

Goal 2: Continuously monitor pollinator abundance and diversity within the City of Ames and urban fringe area over the next 10 years.

Strategy 1: Over the next 10 years, support pollinator species, including those listed as imperiled by federal, state, and research authorities, in order to begin restoring pollinator populations.

Education

Action 1: Deliver public outreach materials (posters, brochures, etc.) annually, focusing on five different pollinators native to Iowa and how residents, community gardens, and businesses can help them.

Action 2: Create a tailored list of native pollinators, both common and imperiled, that will likely benefit from urban conservation efforts in Ames.

Implementation Steps

- Include these native pollinators' host and foraging plants by year 2024.

Action 3: Include the host plants and nectar/pollen plants of imperiled pollinators in the City of Ames' native planting lists and planting projects.

Action 4: Present basic background information on native pollinators to three entities per year, including entities that are: private, public, non-profits, government, HOAs, and businesses.

Action 5: Build citizen understanding of ecologically-beneficial green spaces through signage along with progressive educational and marketing campaigns each year.

Implementation Steps

- Signage will include QR codes that link members of the public to additional information online through the Ames Pollinator-Friendly Community web page or other sources.

Research

Action 1: By 2024, assess and create a baseline of current pollinator abundance and number of species in the City of Ames and urban fringe, and report findings to the public.

Action 2: Create a simplified, Story County-specific pollinator checklist to engage the public and to possibly be used for crowd-sourced/community science data collection.

Action 3: Hold annual pollinator survey (assessing abundance and number of species) beginning in 2024, utilizing local community science programs in conjunction with a standardized survey. Report findings to the public annually.

Implementation Steps

- Create a group for Ames on iNaturalist, Bumble Bee Watch, the forthcoming Iowa Bumble Bee Atlas, and other online community science organizations.

Partnerships

Action 1: Engage with Insects of Iowa, Reiman Gardens' Iowa Butterfly Survey Network (IBSN) and the forthcoming Iowa Bumble Bee Atlas to train and organize community scientists. Bird Friendly Iowa may have information on how to create useful species checklists for the public, and provide a volunteer base to participate in surveys.

Goal 3: Provide a healthier environment for pollinators.

Native bees can be negatively affected by pesticides applied 12 years ago[1].

1 Anderson and Harmon-Threatt, "Chronic Contact with Realistic Soil Concentrations of Imidacloprid Affects the Mass, Immature Development Speed, and Adult Longevity of Solitary Bees."

Goal 3: Provide a healthier environment for pollinators.

Strategy 1: Over the next 10 years, reduce pesticide use, especially that of neonicotinoids, across the City of Ames.

Education

Action 1: Educate HOA board members and individual households on the possible harmful effects of pesticides and fertilizers on the health of pollinators, the environment, pets, and humans.

Implementation Steps

• Offer best management practices for pest control (e.g., integrated pest management (IPM), reduced-risk pesticides, and possible organic options).

Action 2: Create educational materials describing harmful vs. harmless insects.

Implementation Steps

• Distribute information about solitary wasps (which are harmless to humans) versus yellow jackets (which may pose a threat).

Action 3: Encourage local nurseries/greenhouses/growers to provide “bee-safe”, insecticide-free plants and seeds.

Action 4: Every two years, have fifty homeowners sign a pledge to end or lower their outdoor pesticide use (including neonicotinoids).

Policy

Action 1: Present the impacts of pesticides on pollinators to the Ames City Council.

Action 2: Work with the City of Ames to stop all use of neonicotinoid insecticide use by 2024 in Parks.

Action 3: Continually assess City of Ames mosquito fogging and other pest control for best management practices and the implementation of Integrated Pest Management; especially in park and playground areas, along with preschools and daycares to lower child exposure to pesticides.

Action 4: The City of Ames will work with 20 businesses, HOAs, ISU, and churches with large amounts of turf and lawn to sign a pledge to the City to become neonicotinoid-free by 2033.

Action 5: On City lands and facilities, work to create best management practices that align with the pollinator plan goals and City of Ames parks.

Implementation Steps

- Reference the City of Ames Green Infrastructure Maintenance and Management Plan to aid in creating best management practices for city stormwater infrastructure.

Research

Action 1: Seek and apply for grants that support the City of Ames to create pollinator-supportive action concerning pesticides and neonicotinoids.

Goal 4: Deliver marketing strategies and materials to amplify community awareness of the Ames Pollinator - Friendly Community Plan.

The honey bee is not native to Iowa. Iowa alone has over 300 species of native bees[1].

1 Iowa DNR, “Pollinators.”

Goal 4: Deliver marketing strategies and materials to amplify community awareness of the Ames Pollinator-Friendly Community Plan.

Strategy 1: Establish an Ames Pollinator-Friendly Planning Team comprised of Ames residents to oversee the implementation of the 10-year Ames Pollinator-Friendly Community Plan.

Action 1: The task force will meet at least three times per year to set annual goals, move the plan forward, and make necessary updates and adjustments to the plan.

Action 2: Members will provide updates as needed to the Ames City Council on the plan's progress and accomplishments.

Action 3: Members will provide an annual report updating the public on plan progress and accomplishments.

Action 4: Members will create an annual display at the Ames EcoFair to communicate plan progress and accomplishments to the community in person.

Action 5: Members will create a communication and marketing plan to inform the public about the plan and ongoing projects.

Strategy 2: Develop infrastructure to deliver the plan and its accomplishments to the public each year.

Action 1: Create a webpage to centralize digital information about the Ames Pollinator-Friendly Community Plan.

Implementation Steps

- Webpage could include plan progress, links to Bird Friendly Iowa and other pollinator resources, links to award and rebate applications, informational documents, and an interactive pollinator habitat map showcasing pollinator habitat created through the plan's efforts.

Action 2: Create a logo that is identifiable with the Ames Pollinator-Friendly Community Plan.

Action 3: Create a mascot, or official pollinator, for the City of Ames.

Action 4: Create or utilize existing social media accounts to communicate the plan's goals, progress, events, and ways to be involved.

Implementation Steps

- Assign an administrator and moderator for social media accounts.
- Create an annual social media plan for accounts.

Action 5: Create a mobile display to rotate among city buildings and other areas with substantial public interface to provide information about the Ames Pollinator-Friendly Community Plan.

Strategy 3: Celebrate pollinators and community action through an annual, public pollinator celebration during National Pollinator Week at the Ames Farmers Market or other public event.

Action 1: Recognize and award businesses, HOAs, churches, etc. for incorporating pollinator-friendly habitat and practices.

Action 2: Hold an annual pollinator garden tour and native plant giveaway.

Action 3: Award "Pollinator Garden of the Year" to City of Ames residents.

Implementation Steps

- Offer different classes in which to enter private pollinator gardens; small, medium, and large projects. Gardens evaluated on nesting/food resources and management.

Action 4: Mayor reads Proclamation announcing the official pollinator of the City of Ames, and Ames' pledge to support and protect pollinators and their health.

Partnerships

Action 1: Engage annually with organizations such as the Iowa DNR and USDA-NRCS Urban Agriculture programs to support urban and urban-fringe habitat enhancement efforts.

Action 2: Engage with statewide not-for-profits to stay informed about new research and ideas.

Iowa's At-Risk Pollinator Species

Federal and State Endangered Species

- Rusty-patched Bumble Bee..... *Bombus affinis*
- Butterflies Dakota Skipper..... *Hesperia dacotae*
- Common Ringlet..... *Coenonympha tullia*

State Threatened Species:

- Poweshiek Skipperling..... *Oarisma poweshiek*
- Byssus Skipper..... *Problema byssus*
- Mulberry Wing..... *Poanes massasoit*
- Silvery Blue..... *Glaucopsyche lygdamus*
- Baltimore Checkerspot..... *Euphydryas phaeton*

State Species of Special Concern:

- Dreamy Duskywing..... *Erynnis icelus*
- Sleepy Duskywing..... *Erynnis brizo*
- Columbine Duskywing..... *Erynnis lucilius*
- Wild Indigo Duskywing..... *Erynnis baptisiae*
- Ottoe Skipper..... *Hesperia ottoe*
- Leonardus (Leonard's) Skipper..... *Hesperia leonardus*
- Pawnee Skipper..... *Hesperia leonardus pawnee* (subspecies)
- Beardgrass Skipper..... *Atrytone arogos*
- Zabulon Skipper..... *Poanes zabulon*
- Broad-winged Skipper..... *Poanes viator*
- Sedge Skipper..... *Euphyes dion*
- Two-spotted Skipper..... *Euphyes bimacula*
- Dusted Skipper..... *Atrytonopsis hianna*
- Pepper and-Salt Skipper..... *Amblyscirtes hegon*
- Pipevine Swallowtail..... *Battus philenor*
- Zebra Swallowtail..... *Protographium marcellus*
- Olympia Marble..... *Euchloe olympia*
- Purplish Copper..... *Lycaena helloides*
- Acadian Hairstreak..... *Satyrium acadica*
- Edward's Hairstreak..... *Satyrium edwardsii*
- Hickory Hairstreak..... *Satyrium caryaevorus*
- Striped Hairstreak..... *Satyrium liparops*
- Swamp Metalmark..... *Calephelis muticum*
- Regal Fritillary..... *Speyeria idalia*
- Ozark Baltimore Checkerspot..... *Euphydryas phaeton ozarka* (subspecies)

Species that are vulnerable to extinction/declines, but not listed by the state or federal government:

- Monarch Butterfly..... *Danaus plexippus*
- American Bumble Bee..... *Bombus pensylvanicus*
- Southern-Plains Bumble Bee..... *Bombus fraternus*
- Ashton's Cuckoo Bumble Bee..... *Bombus bohemicus*
- Yellow Bumble Bee..... *Bombus fervidus*

City of Ames' At-Risk Pollinators

The following species are listed by the federal or state governments, or listed by the IUCN seen in Story County or adjacent counties in the last 10 years (**except** the Dakota skipper, the Poweshiek skipperling, and the Baltimore checkerspot, which have **not** been documented in this area in the last 10 years), and whose host/ foraging plants are native to Story County and/or adjacent counties.

Common Name	Species Name	Federal Listing	State Listing	IUCN Listing	Picture	Butterfly Host/Bee Forage Plant	Habitat
Poweshiek Skipperling	*Oarisma poweshiek*	Endangered	Threatened	Critically Endangered		Indian grass, Prairie dropseed, Big bluestem	Prairie fens, Wet to dry remnant prairies
Dakota Skipper	*Hesperia dacotae*	Threatened	Endangered	Endangered		Little bluestem, other native grasses	Wet and dry remnant prairies
Common Ringlet	*Coenonympha tullia*	N/A	Endangered	N/A		Grasses; specifics are unknown	Grassy open areas, dry prairies
Rusty-patched Bumble Bee	*Bombus affinis*	Endangered	N/A	Critically Endangered		Generalist	Prairies and shrublands, often near woods; urban gardens
Southern Plains Bumble Bee	*Bombus fraternus*	N/A	N/A	Endangered		Generalist	Prairies/ grasslands, some gardens
American Bumble Bee	*Bombus pensylvanicus*	N/A	N/A	Vulnerable		Generalist	Grasslands

City of Ames' At-Risk Pollinators

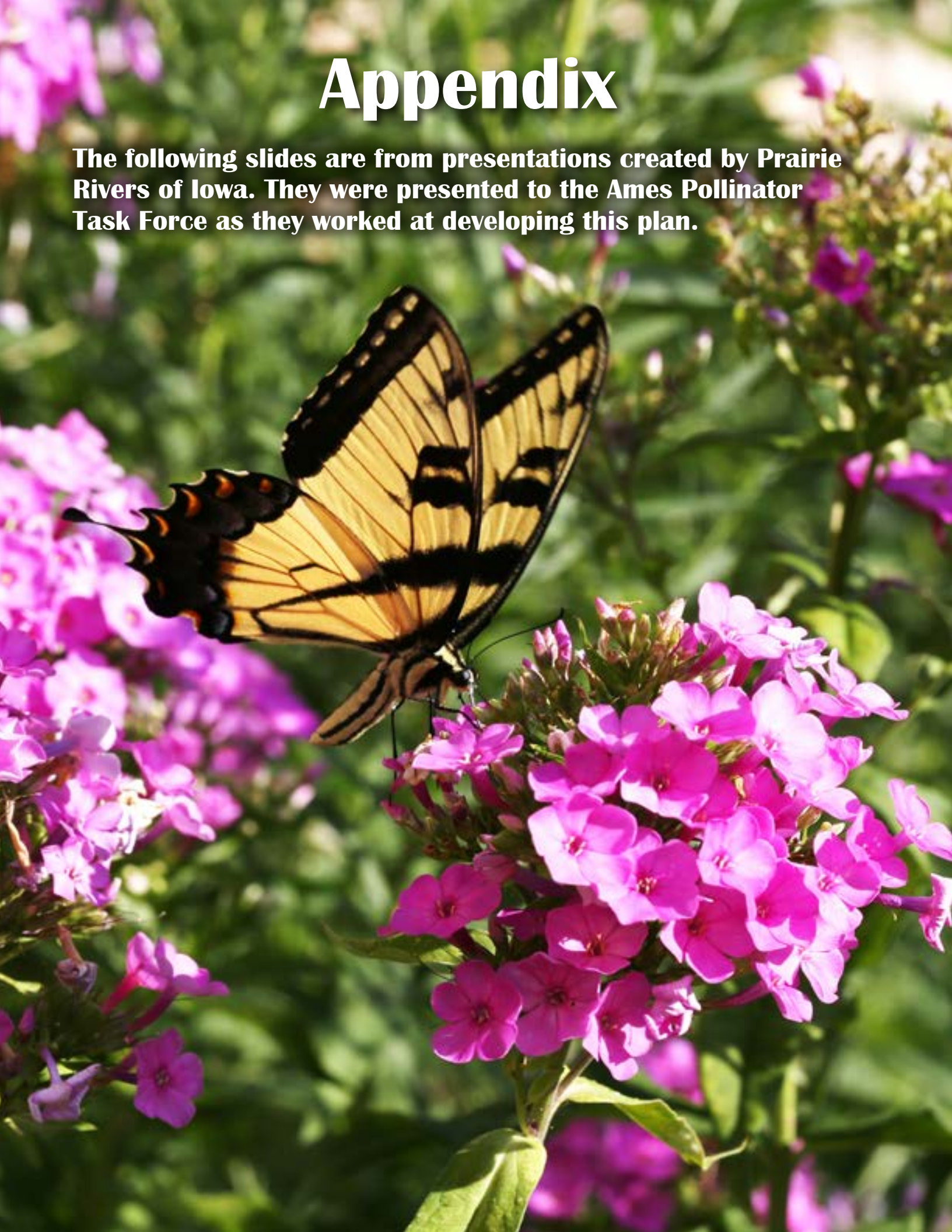
Common Name	Species Name	Federal Listing	State Listing	IUCN Listing	Picture	Butterfly Host/Bee Forage Plant	Habitat
Mulberry Wing	*Poanes massasoit*	N/A	Threatened	N/A		Tussock sedge (*Carex stricta*), possibly others	Fens, marshes, wet prairies
Acadian Hairstreak	*Satyrium acadica*	N/A	Special Concern	N/A		Willows	Native wet prairies, fens, sedge meadows, marshes
Monarch Butterfly	*Danaus plexippus*	Candidate	N/A	Endangered		Milkweeds	Open and disturbed areas
Hickory Hairstreak	*Satyrium caryaevorus*	N/A	Special Concern	N/A		Hickory, Ash, Chestnut, and Oak	Deciduous forests, second-growth woods
Striped Hairstreak	*Satyrium liparops*	N/A	Special Concern	N/A		American plum, Willow, Oak	Deciduous forest openings, prairie streamsides
Regal Fritillary	*Speyeria idalia*	N/A	Special Concern	Vulnerable		Bird's foot violet, maybe other violet species	Large, high-quality tallgrass prairie remnants

City of Ames' At-Risk Pollinators

Common Name	Species Name	Federal Listing	State Listing	IUCN Listing	Picture	Butterfly Host/Bee Forage Plant	Habitat
Sedge (Dion) Skipper	*Euphyes dion*	N/A	Special Concern	N/A		*Carex lacustris*, woolgrass, maybe other sedges as well	Wetlands, bogs
Wild Indigo Duskywing	*Erynnis baptisiae*	N/A	Special Concern	N/A		Wild indigo, lupine, crown vetch	Dry prairies, open woods
Pipevine Swallowtail	*Battus philenor*	N/A	Special Concern	Least Concern		*Aristolochia* species: Virginia snakeroot and others	Open woods, old growth forests, rocky woodlands
Zebra Swallowtail	*Protographium marcellus*	N/A	Special Concern	N/A		Pawpaw	Mesic, lowland forests, near rivers
Dreamy Duskywing	*Erynnis icelus*	N/A	Special Concern	N/A		Willow, Poplar, Aspen, Birch	Woodland openings and edges
Columbine Duskywing	*Erynnis lucilius*	N/A	Special Concern	N/A		Wild Columbine (*Aquilegia Canadensis*) sometimes *A. vulgaris*	Dry prairies, rocky deciduous forest edges, ravines
Two-spotted Skipper	*Euphyes bimacula*	N/A	Special Concern	N/A		Hairyfruit sedge (*Carex trichocarpa*) maybe other *Carex* species	Wet prairies, bogs, marshes
Baltimore Checkerspot	*Euphydryas phaeton*	N/A	Threatened	N/A		Turtlehead, false foxglove, and English and Common plantain	High-quality fens, open woodland seeps, marshes

Appendix

The following slides are from presentations created by Prairie Rivers of Iowa. They were presented to the Ames Pollinator Task Force as they worked at developing this plan.



The State of Iowa Pollinators:

This presentation was given at the first Ames Pollinator-Friendly Community Task Force meeting on April 20, 2022. It provides a summary of pollinator life history traits, the connections between pollinator conservation and the wellbeing of Iowans, and Iowa's at-risk pollinator species.

PRAIRIE RIVERS of Iowa

The State of Iowa Pollinators

PRAIRIE RIVERS of Iowa

JESSICA BUTTERS

What are Pollinators?

- Any animal that moves pollen from one flower to another
- Bees, flies, butterflies, skippers, moths, beetles, birds, bats

What are Pollinators?

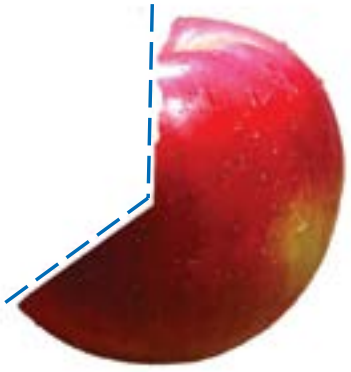
- Any animal that moves pollen from one flower to another
- **Bees**, flies, **butterflies, skippers**, moths, beetles, birds, bats

Why are They Important?

- 1/3rd of world crops[1]

1) Klein et al. 2007. Importance of pollinators in changing landscapes for world crops.
2) Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). 2016. Summary for policy makers of the assessment report of the IPBES on pollinators, pollination and food production.
3) Ollerton et al. 2011. How many flowering plants are pollinated by animals?

Why are They Important?



- 1/3rd of world crops[1]
- $235-577 Billion globally[2]
- > 87% of flowering plants need pollinators[3]

1) Klein et al. 2007. Importance of pollinators in changing landscapes for world crops.
2) Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). 2016. Summary for policy makers of the assessment report of the IPBES on pollinators, pollination and food production.
3) Ollerton et al. 2011. How many flowering plants are pollinated by animals?

Lives of Pollinators

Butterflies

- 110 Butterfly species
- 2,000 Moth species

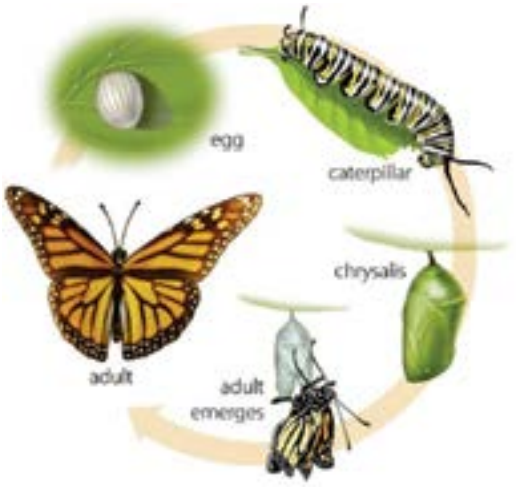




Bisected honey locust


Snowberry clearwing

Butterflies



- Complete metamorphosis
- Ectothermic; no internal temperature regulation. Use sun/shivering for warmth
- Herbivores
  - Larvae (caterpillars) eat leaves
  - Adults (butterflies) drink nectar

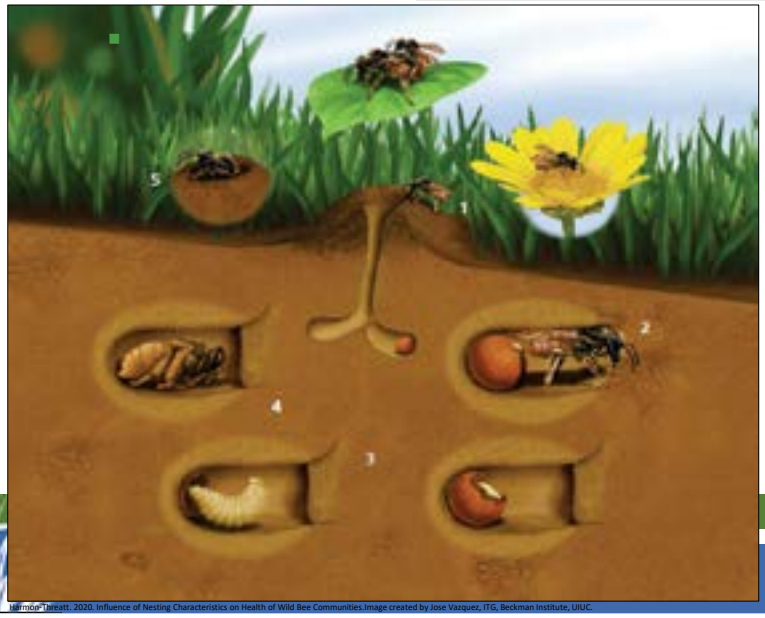
How do Butterflies live?

- Lay eggs on leaves of host plant
  - Can be generalists or specialists
  - Monarchs and milkweeds
  - Black swallowtail and carrot family
- Some caterpillars utilize ant nests!
  - Edward's hairstreak (*Satyrium edwardsii*)
    - Species of concern in Iowa

Bees

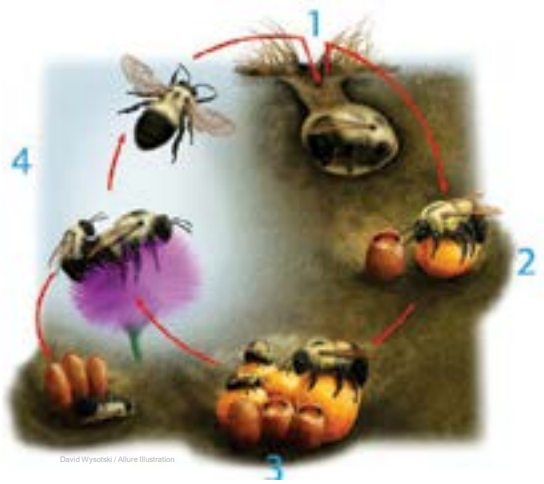
- 400 Native bee species
- Honey bee: just 1 nonnative bee species
- Ectothermic
- Eat pollen and nectar

How do Bees live?



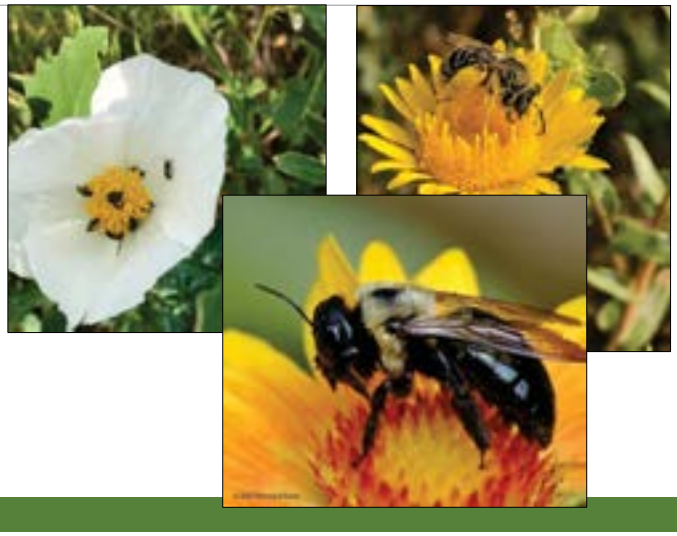
- Complete metamorphosis
- Most (> 70%) nest in the ground!
- Others nest in stems/abandoned burrows
- Most are solitary
- One female
  - Builds nests
  - Collects pollen for young
  - Lays eggs
- Do not live multiple years

How do Bees live?



How do Bees live?

- Travel distance:
  - Lasioglossom (0.5cm): as short as 10 meters[1]
  - Xylocopa (2.3cm): up to 13 miles![1]
  - No more than 150-200m distance for all bees[2,3]
- Very effective pollinators!



1) Williams and Winfree. 2009. Native Bee Benefits. Bryn Mawr College and Rutgers University
2) Zurbuchen et al. 2010. Long foraging distances impose high costs on offspring production in solitary bees.
3) Hoffman et al. 2020. Foraging distances in six species of solitary bees with body lengths of 6 to 15 mm, inferred from individual tagging, suggest 150 m rule-of-thumb for flower strip distances.

How can Pollinator Conservation serve Iowans?

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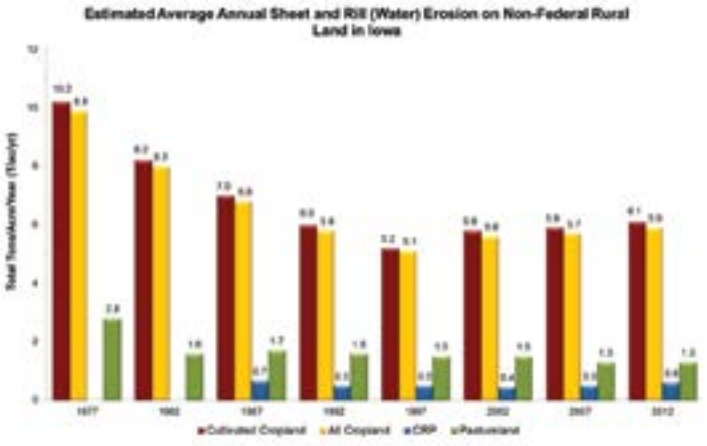
Current Iowa Landscape

- Iowa struggles with erosion, which impacts:
  - Amount/quality of topsoil on fields
  - Treated soil/water entering our waterways
    - Impacts areas we swim, canoe, fish, and sometimes our drinking water



USDA-NRCS 2015 National Resources Inventory Summary Report. Aaron Sassman, Gerald Miller. Iowa State University. Updated Jan 29, 2016

Current Iowa Landscape

- Iowa receives 28-36 inches of rain/year[1]
  - Regardless of the area you live in
- Up to 977,500 gal rain/year
  - Runoff pollutes storm drains which lead to streams
  - Issues with stream erosion

1) Clean Water Iowa. https://www.cleanwateriowa.org/native-turf

Increasing Native Habitat is Key to Iowa Health

Pollinator habitat = healthy habitat

Increase native plant cover

Increase root content of soil

Sequester carbon
Roots fix carbon into soil

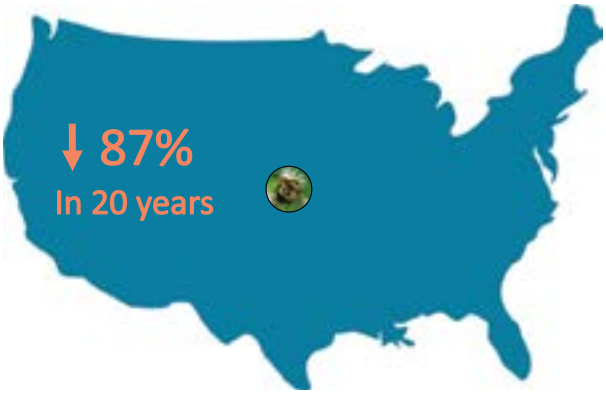
Filter water ways
Cleaner Iowa water

Sustainable and Cleaner Management Systems

Iowa's Imperiled Pollinators

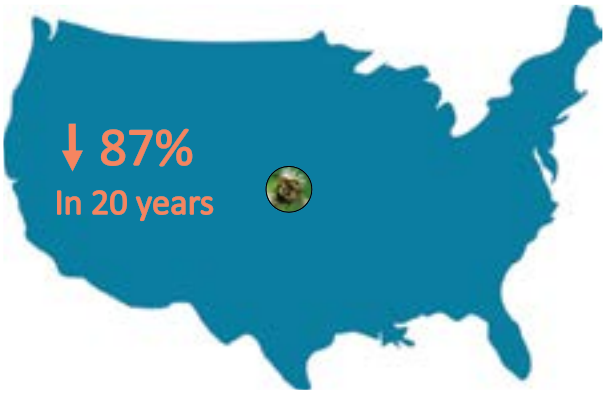
Flagship Pollinator Declines

Flagship Pollinator Declines



1) Xerces Society. 2021. Rusty Patched Bumble Bee. https://www.xerces.org/endangered-species/species-profiles/at-risk-invertebrates/bumble-bees/rusty-patched-bumble-bee
2) Bradbury et al. 2017. Iowa monarch conservation, pest management, and crop production. *Integrated Crop Management Conference*. Iowa State University.

Flagship Pollinator Declines



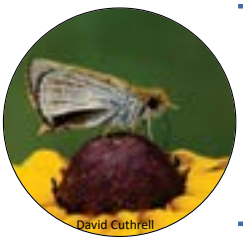
1) Xerces Society. 2021. Rusty Patched Bumble Bee. https://www.xerces.org/endangered-species/species-profiles/at-risk-invertebrates/bumble-bees/rusty-patched-bumble-bee
2) Bradbury et al. 2017. Iowa monarch conservation, pest management, and crop production. *Integrated Crop Management Conference*. Iowa State University.

Endangered

Iowa's Endangered Pollinators

National Level (USFWS)

- Rusty-patched bumble bee (*Bombus affinis*)[1]
  - Pathogens, pesticides, habitat loss
- Poweshiek skipperling (*Oarisma poweshiek*)[1]
  - Habitat loss



State Level (Iowa DNR)

- Dakota Skipper (*Hesperia dacotae*)[2]
- Common Ringlet (*Coenonympha tullia*)[2]

Endangered: the species is in danger of extinction throughout all or a significant portion of its range.

Threatened

Iowa's Threatened Pollinators (DNR)

- Byssus Skipper (*Problema byssus*)
- Mulberry Wing (*Poanes massasoit*)
- Silvery Blue (*Glaucopsyche lygdamus*)
- Baltimore Checkerspot (*Euphydryas phaeton*)

Threatened: likely to become endangered within the foreseeable future throughout all or a significant portion of its range

Iowa Butterflies of Special Concern:

Iowa DNR:

- 25 Butterfly species, including
  - 14 Skippers
  - 2 Swallowtails
  - 4 Hairstreaks
  - 1 Marble white
  - 1 Metalmark
  - 1 Copper
  - 1 Baltimore
  - Regal fritillary
- Moths and Bees are not tracked by the iDNR!

Swamp Metal Mark

Olympia Marble

Special Concern: may become threatened if situation continues or worsens

Vulnerable Iowa Bees:

Vulnerable bees tracked by IUCN* and Xerces Society:

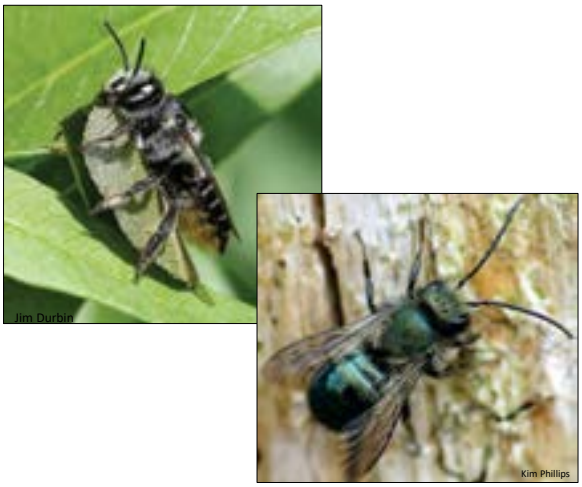
4 Bumble bees

- Southern Plains (*Bombus fraternus*)
- Yellow (*Bombus fervidus*)
- American (*Bombus pensylvanicus*)
- Ashton's cuckoo (*Bombus bohemicus*)

*International Union for Conservation of Nature

Vulnerable: IUCN Redlist: Higher risk of extinction due to rapid population declines of > 30-50% in past 10 years or population fewer than 1,000 individuals

What about smaller native bees?

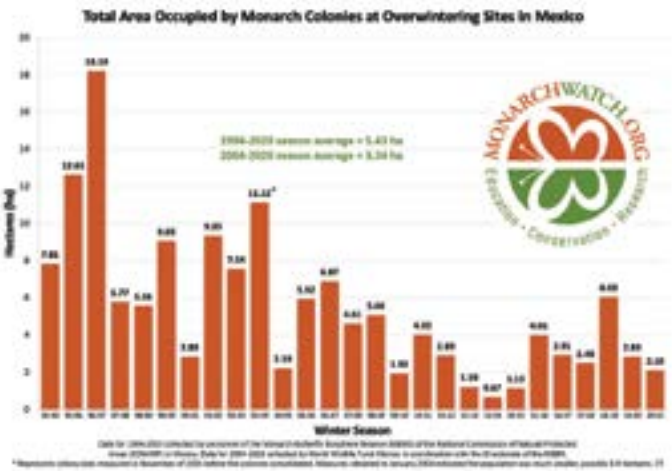


- We don't know
  - IUCN + Xerces Society:
  - 50% Leafcutter bee species and
  - 27% mason bee species "at risk"

https://www.xerces.org/endangered-species/wild-bees

Monarch Declines

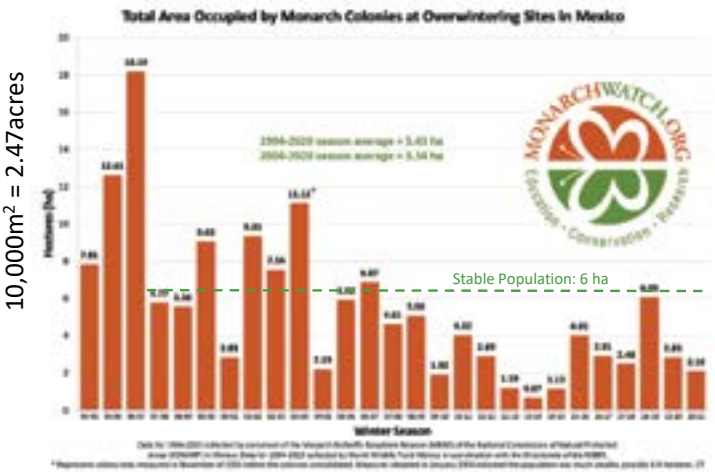
10,000m² = 2.47acres



- Candidate (Dec. 2020) to be listed as federally endangered, threatened, or of special concern
- Iowa has the Eastern monarch population
  - The western population is west of the Rockies and overwinters in California instead of Mexico
- Xerces Society and NatureServe concluded it is "critically imperiled" in 2014
  - 1) Herbicides lowered milkweed breeding habitat
  - 2) Logging in their over-wintering areas
  - 3) Climate change/severe weather

Accessed through National Wildlife Federation Blog; Population stability adapted by David Stein from World Wildlife Fund

Monarch Declines



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Accessed through National Wildlife Federation Blog; Population stability adapted by David Stein from World Wildlife Fund

Honey Bee Trends

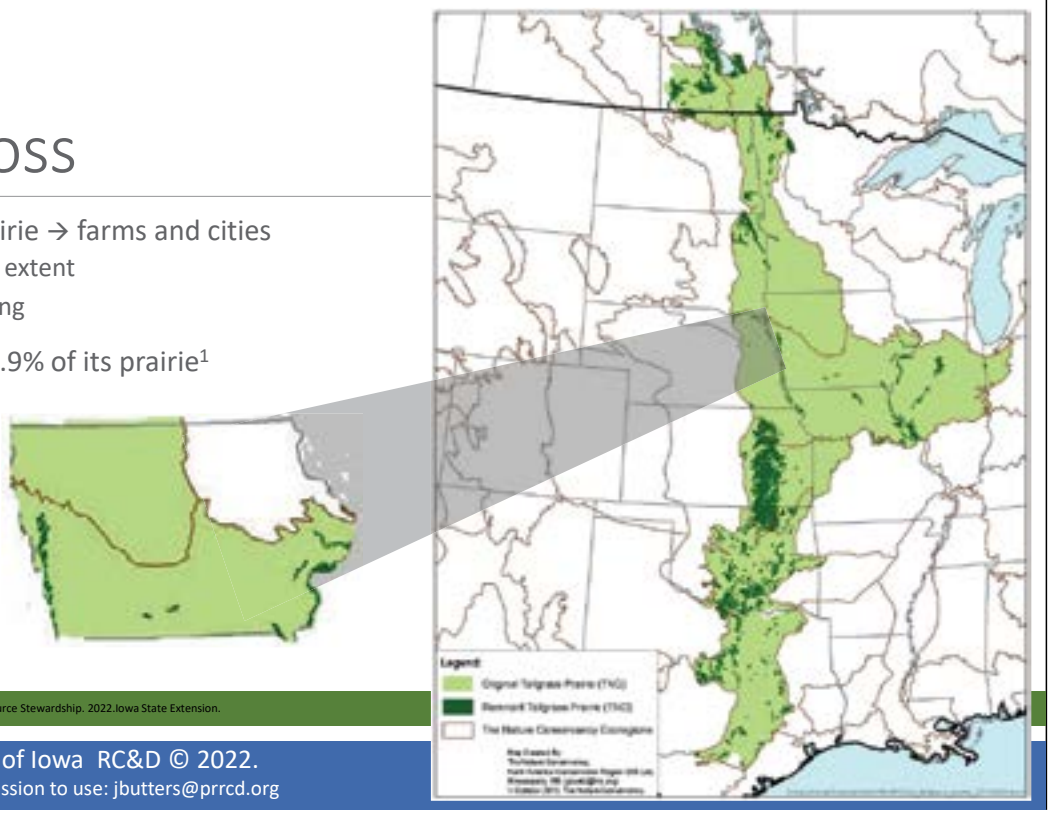
- State of Iowa had largest winter honey bee loss of all states in US
  - Preliminary analysis by Bee Informed*
  - Overall US had 2nd highest loss on record
- In the top 7 reported reasons:
  - Pathogens, starvation, weather, pesticides

* Nathalie Steinhauer1, Dan Aurell2, Selina Bruckner2, Mikayla Wilson1, Karen Rennich1, Dennis vanEngelsdorp1, Geoffrey Williams2
1Department of Entomology, University of Maryland, College Park, MD, USA
2Department of Entomology & Plant Pathology, Auburn University, Auburn, AL, USA
Corresponding Authors: nsteinha@umd.edu (NS) & williams@auburn.edu (GW)

Drivers of Decline in Iowa

Habitat Loss

- Land use change: prairie → farms and cities
  - Light green = original extent
  - Dark green = remaining
- Iowa has lost over 99.9% of its prairie[1]
  - < 0.1% remaining



1) Prairie Restoration Habitat Headquarters, Natural Resource Stewardship. 2022.Iowa State Extension.

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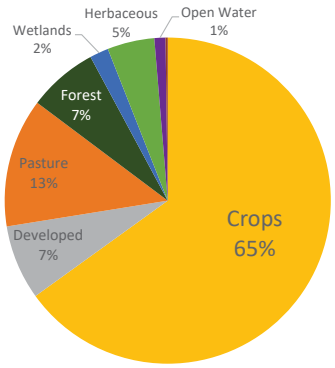
Intense Landscapes

- > 85% of Iowa is an altered
  - Urban + Farmland



Based on: Ethan M. Dahlhauser. 2013. Iowa Department of Natural Resources. GIS Library and NRCS GeoSpatial Data Gateway

Intense Landscapes

- Urban sprawl increases disturbance
- If 50% or more of an area is concrete or buildings, pollinator populations decline[1]
  - Especially ground-nesting bees and specialists

1) Wenzel et al. 2020. How urbanization is driving pollinator diversity and pollination – A systematic review.

Other Threats

Tetraloniella cressoniana, the Blue Sage bee

Besides loss of native habitat and increase of nonnative plants:

- Insecticides and Pesticides
- Pathogens
  - From domestic bees and weakened immume systems
- Climate Change
  - Mismatches timing of plant-pollinator interactions
- Lack of Data/tracking

Good News

Declining pollinator species of Iowa seen here/adjacent counties in last 10 years

15/37 Species Total

Declining pollinator species of Iowa seen here/adjacent counties in last 10 years*

- Byssus Skipper, **State threatened**, Polk 2011
- Dreamy Duskywing, **Spec. Concern**, Polk 2014
- Columbine Duskywing, Polk 2018
- Wild Indigo Duskywing, Polk 2021, Story 2014
- Zabulon Skipper, Polk 2020
- Sedge (or Dion) Skipper, Story 2020
- Pipevine Swallowtail, Story 2013
- Zebra swallowtail, Story 2012
- Acadian Hairstreak, Jasper 2021
- Striped Hairstreak, Story 2020
- Regal Fritillary, Polk 2021
- Rusty-patched bumble bee, Story 2021. **Endangered**
- American bumble bee, Polk 2020. **Vulnerable**
- Yellow bumble bee, Marion, 2021
- Plains bumble bee, Story 2020, Boone 2021

Picking specific target species for conservation efforts may help support lesser-known or untracked species

*Utilized Insects of Iowa and iNaturalist; Checked with Iowa DNR's Natural Areas Inventory

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How to Support Pollinators

- Increase amount of healthy native plants
  - Food and nesting resources
  - Lowering pesticides
- Increase Awareness and Education
  - Citizens, businesses, urban and urban-rural interface
  - Homeowner associations, property managers
- Promote sustainable yard management
  - Lower pesticides
  - Increase native plant cover

Augochlorini bee on prairie rose

Progress

Bombus impatiens on blazing star

- 97.2% of park-goers want to support bees
  - Minneapolis, 2018[1]
- 80% of survey respondents believed pollinator loss is somewhat serious or worse[2]
  - 2020 survey of Conservation in the West Survey
  - Rocky Mountain states: CO, WY, MT, UT, NM, etc.
- Increase in citizen science participation
  - Bumble Bee Watch
  - iNaturalist
- The pollinator movement has momentum!
  - We can use it for effective and lasting pollinator support

1) Ramer et al. 2019. Exploring park visitor perceptions of 'flowering bee lawns' in neighborhood parks in Minneapolis, MN, US. *Landscape and Urban Planning*
2) Shepherd. 2020. Xerces Society, from *Conservation in the West Poll*, 2020. The Colorado College State of the Rockies Project.

Pesticides and Pollinators:

This presentation was given at the Task Force meeting on May 24, 2022. It summarizes pesticide use in the United States and Iowa, the different classes of insecticides and their specific mechanisms, and the overall impact these chemicals have on pollinators. We also discussed which pesticides seem to be the most toxic, and how to reduce urban pesticide use.

PRAIRIE RIVERS of Iowa

Pesticides and Pollinators

PRAIRIE RIVERS of Iowa

JESSICA BUTTERS

Pesticides

- Substance that destroys, repels, prevents, or mitigates a pest – EPA
- Pesticide types:
  - Herbicide, Insecticide, fungicide, rodenticide

Plants Insects Fungi Rodents

Pesticides

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Pesticides

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- Pesticide types:
  - Herbicide, insecticide, fungicide, rodenticide

Plants Insects Fungi Rodents

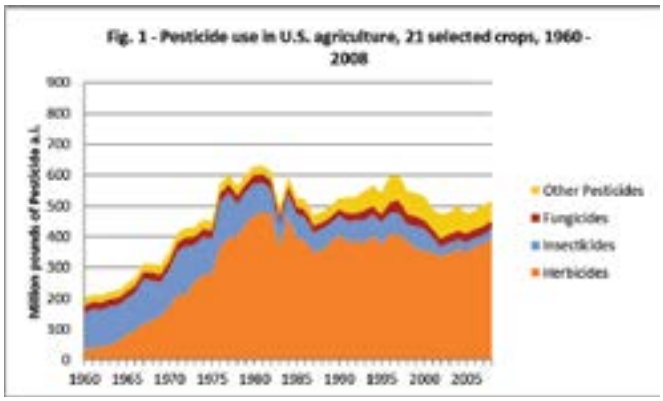
Pesticides

  - Top pesticides in the US:
  - Herbicide: Glyphosate (Roundup)[1]
  - Insecticide: Pyrethroids[2]

1) Fernandez-Cornejo, Jorge. 2015. "Managing Glyphosate Resistance Is More Cost Effective than Ignoring Resistance." Accessed May 13, 2022. http://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=78310.
2) Iowa State University Extension and Outreach. "Getting to Know Popular Insecticides Used in Iowa Field Crops | Integrated Crop Management." Accessed May 16, 2022. https://crops.extension.iastate.edu/encyclopedia/getting-know-popular-insecticides-used-iowa-field-crops#:~:text=It%20is%20no%20surprise%20that,(USDA%2DNASS%202019).

USA Pesticide Use

- Pesticide use peaked in 1981
- Herbicides used the most
- Steadied at around **500 million** lbs/year
  - Insecticide alone: 28.55 million lbs/year
    - Iowa used ~560,000 lbs of insecticide in 2018[1]
- Insecticide *application* appears to have decreased over time
  - Bt corn
  - *Systemic* pesticides



Source: Economic Research Service (ERS) with USDA and proprietary data.

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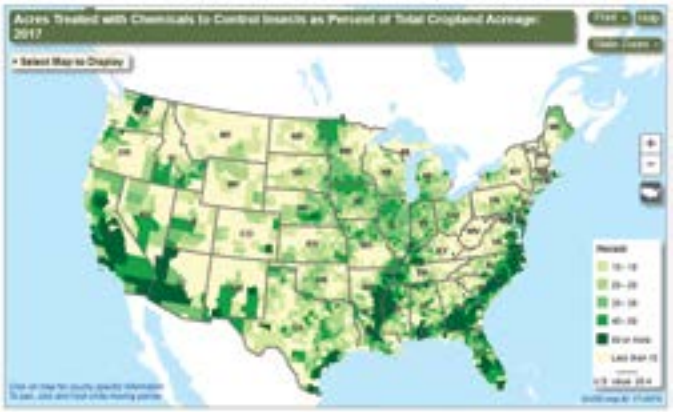
Contact Jessica Butters for permission to use: jbutters@prrcd.org

1) Iowa State University Extension and Outreach. "Getting to Know Popular Insecticides Used in Iowa Field Crops | Integrated Crop Management." Accessed May 16, 2022. https://crops.extension.iastate.edu/encyclopedia/getting-know-popular-insecticides-used-iowa-field-crops#:~:text=It%20is%20no%20surprise%20that,(USDA%2DNASS%202019).

Insecticides

Story County Insecticide Use

- Percentage of cropland acres treated with Insecticide
- National County Average: 28.4% (2017)



Ag Census Web Maps, USDA, National Agricultural Statistics Service. Last Updated: Aug 27, 2020

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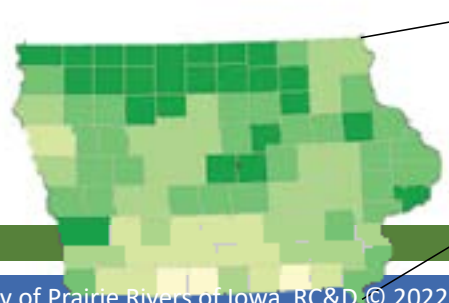
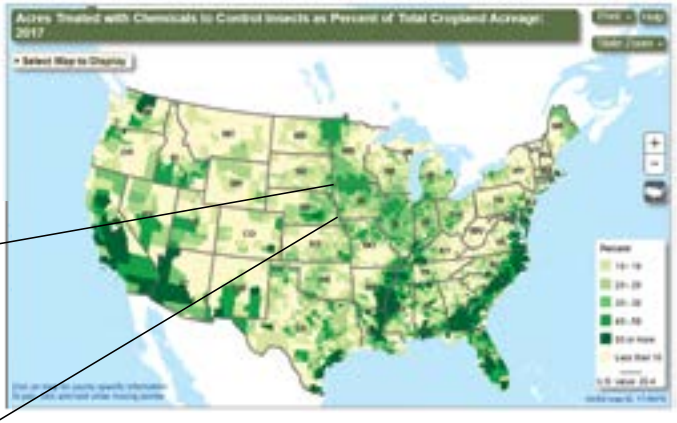
Story County Insecticide Use

- Percentage of cropland acres treated with Insecticide
- National County Average: 28.4% (2017)
- Acres treated with insecticide: **40.04%** (2017)
  - Over 1.4x the national level (140%)





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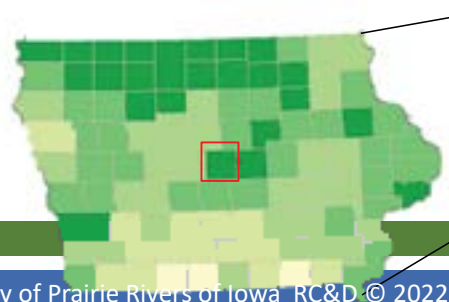

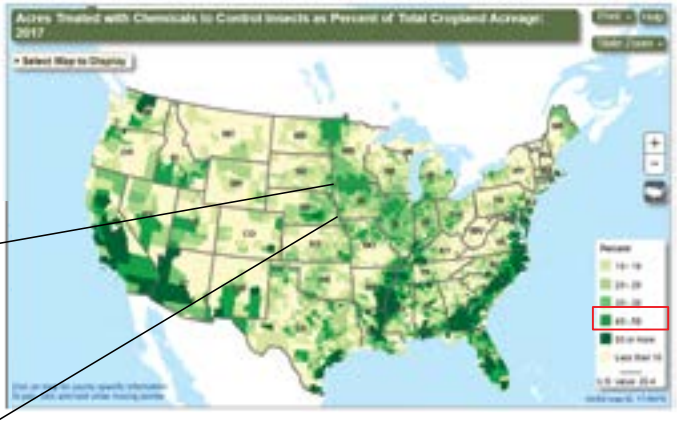

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Ag Census Web Maps, USDA, National Agricultural Statistics Service. Last Updated: Aug 27, 2020

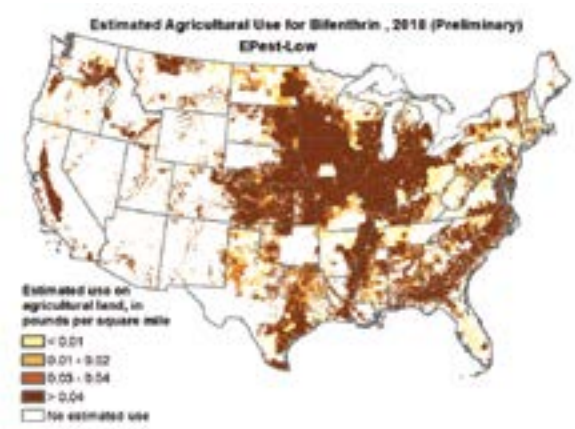
Insecticides

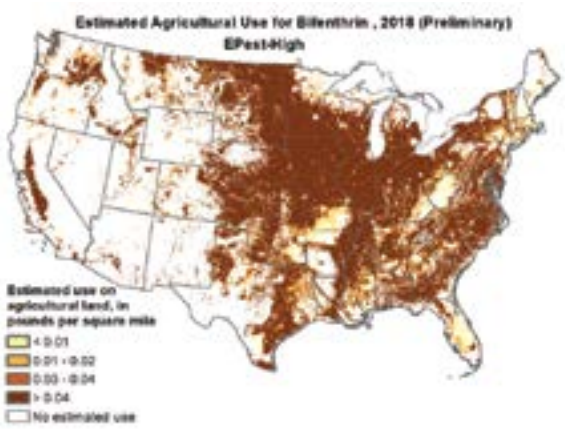
- 3 Groups of insecticides
  1) Pyrethroids
  2) Organophosphates
  3) Neonicotinoids (“neonics”)
  - New Approval: Sulfoxaflor (Isoclast™)[1]
    - systemic class of pesticides for neonic-resistant pests
    - EPA: “…highly toxic to bees and other pollinating insects”
- All produce similar insect response:
  1) Overstimulation
  2) Convulsions / paralysis
  3) “Knockdown” / Death

About **1%** of all insect species are considered pests[2]

1) US EPA, OCSPP. “Decision to Register New Uses for the Insecticide Sulfoxaflor.” Overviews and Factsheets, May 17, 2016. https://www.epa.gov/ingredients-used-pesticide-products/decision-register-new-uses-insecticide-sulfoxaflor.
2) Hopwood et al. 2016. “How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees”.

USGS: EPest-Low vs. EPest-High

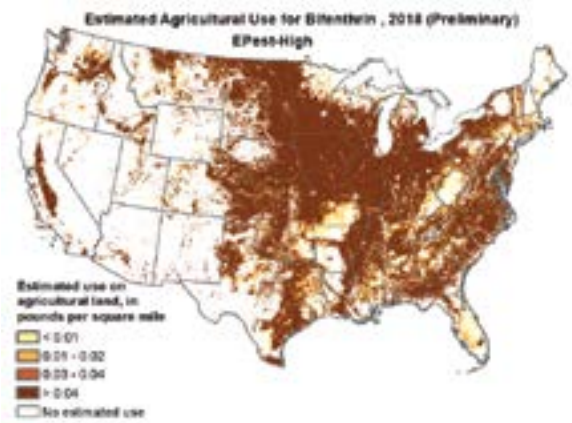




United States Geological Survey, NAWQA. 2021. Pesticide National Synthesis Project. Estimated Annual Agricultural Pesticide Use.

Iowa Insecticide Use

- Pyrethroids
  - "Warrior II", Hero®
  - Bifenthrin
- Block sodium-ion channel gates between nerve cells from closing
- Mimics compound naturally found in chrysanthemum flowers
- Most widely-used insecticide[1]

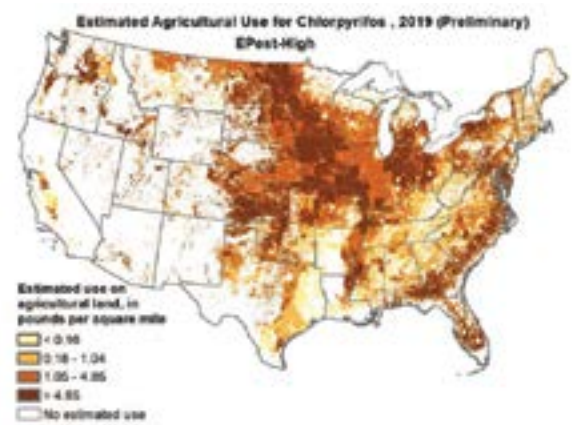


- United States Geological Survey, NAWQA. 2021. Pesticide National Synthesis Project. Estimated Annual Agricultural Pesticide Use.

1) Iowa State University Extension and Outreach. "Getting to Know Popular Insecticides Used in Iowa Field Crops | Integrated Crop Management." Accessed May 16, 2022. https://crops.extension.iastate.edu/encyclopedia/getting-know-popular-insecticides-used-iowa-field-crops#:~:text=It%20is%20no%20surprise%20that,(USDA%2DNASS%202019).

Iowa Insecticide Use

- Organophosphates
  - Lorsban, Fyfanon®
  - Chlorpyrifos
- Binds to enzymes that break down neurotransmitters in insect nervous system
- Can be toxic to mammals/vertebrates
  - Were stockpiled as nerve agents in WWII[1]
    - Not used against Allies



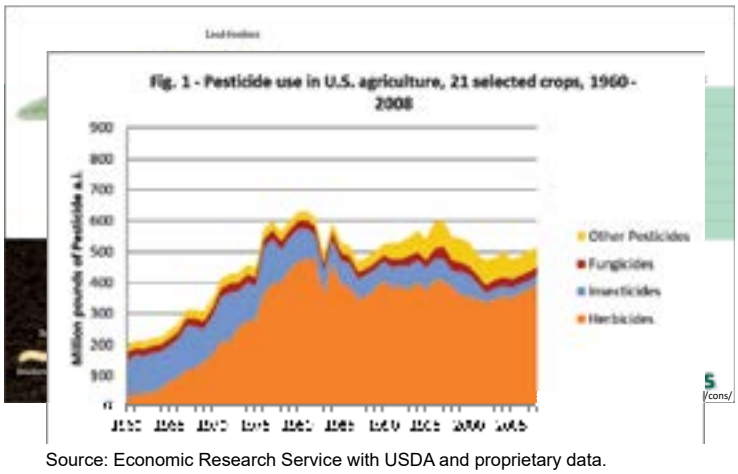
- United States Geological Survey, NAWQA. 2021. Pesticide National Synthesis Project. Estimated Annual Agricultural Pesticide Use.
- Iowa State University Extension and Outreach. "Getting to Know Popular Insecticides Used in Iowa Field Crops | Integrated Crop Management." Accessed May 16, 2022. https://crops.extension.iastate.edu/encyclopedia/getting-know-popular-insecticides-used-iowa-field-crops.
- 1) Gilbert, Steven G. Lessons Learned: Looking Back to Go Forward. Collaborative on Health and Environment. https://www.healthandenvironment.org/environmental-health/social-context/history/gerhard-schrader-father-of-the-nerve-agents

Iowa Insecticide Use

- Neonicotinoids
  - "neonics"
  - Seed treatment or foliar application
  - Cruiser®, Actara®
  - Based on Nicotine
- Blocks enzymes from binding with neurotransmitter
- Created for lower toxicity to vertebrates compared to organophosphates

- United States Geological Survey, NAWQA. 2021. Pesticide National Synthesis Project. Estimated Annual Agricultural Pesticide Use.
- Iowa State University Extension and Outreach. "Getting to Know Popular Insecticides Used in Iowa Field Crops | Integrated Crop Management." Accessed May 16, 2022. https://crops.extension.iastate.edu/encyclopedia/getting-know-popular-insecticides-used-iowa-field-crops.

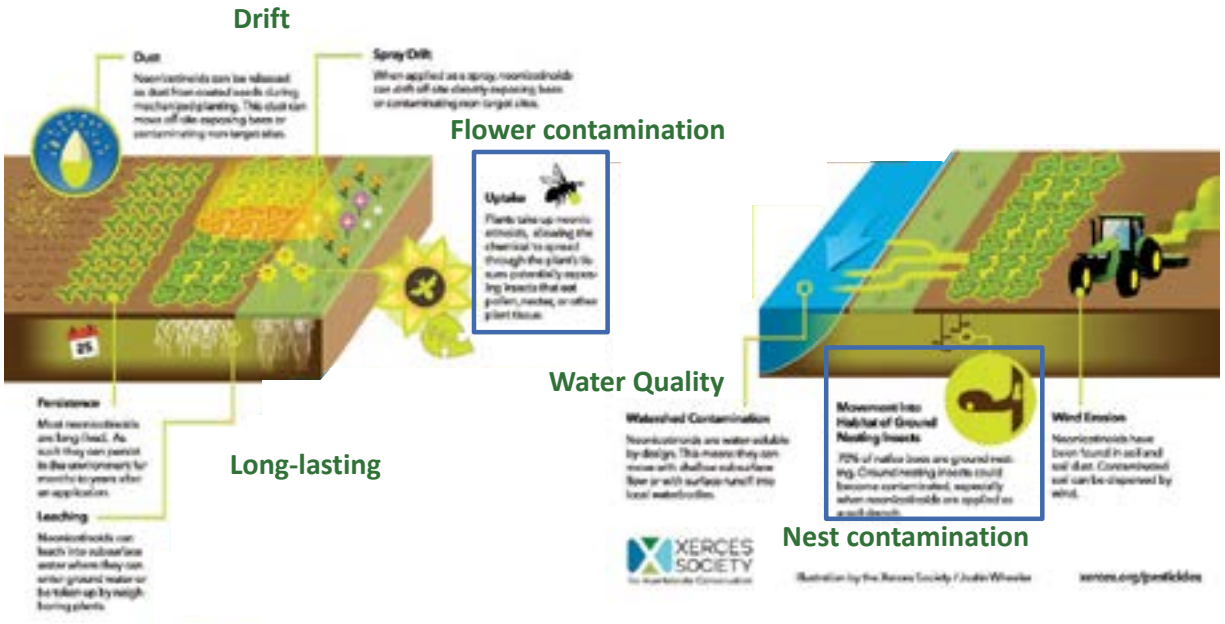
Neonics and Pollinators



Source: Economic Research Service with USDA and proprietary data.

- Neonics are *systemic*
  - Seed and soil treatments provide protection as plant grows[1]
    - Highly water soluble, easily taken up by plants
    - Insecticide found in stems, leaves, roots, **flowers**, **pollen**
  - Treatments are long-lasting
    - From a few weeks in water/soil to max of 6 years in woody plants[3]
- Seed treatments are exempt from the EPA's federal pesticide regulations![2]
  - Assess toxicity, but do not track usage
- Seven compounds considered neonics[1]:
  - Acetamiprid, Clothianidin, Dinotefuran, Imidacloprid, Nitenpyram, Thiocloprid, Thiamethoxam

1) Insects in the City. "What Is a Neonicotinoid?" Texas A&M AgriLife Extension. Accessed May 16, 2022. https://citybugs.tamu.edu/factsheets/ipm/what-is-a-neonicotinoid/
2) Insecticide seed treatments threaten Midwestern waterways. Protecting Aquatic Ecosystems Fact Sheet. 2021. Xerces Society for Invertebrate Conservation
3) Hopwood et all. 2016. "How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees"



https://xerces.org/pesticides/understanding-neonicotinoids

Urban Pesticides

- Use up to 10x the amount per acre than agricultural acres[1]
- US Home and Garden Pesticide use[2]:
  - Herbicides: 28 million lbs (2012)
  - Insecticides: 14 million lbs
- Urban streams consistently higher in insecticide concentrations[3]

https://landscapinginsaltlake.com/what-are-the-pros-and-cons-of-lawn-fertilizers/

1) "What's Happening to the Frogs? | U.S. Fish & Wildlife Service," July 6, 2000. https://fws.gov/story/2000-07/whats-happening-frogs-1.
2) Atwood, Donald, and Claire Paisley-Jones. "Pesticides Industry Sales and Usage: 2008-2012 Market Estimates." Washington, DC: U.S. Environmental Protection Agency, 2017.
3) Mullins, W H, Dennis A Wentz, and Gregg Patterson. "Pesticides Used to Control Weeds, Insects, and Other Pests on Farms and in Urban Areas Can Be Harmful to Humans and the Environment If They Contaminate Our Water Resources," 2017., 24, Based on : NAWQA studies (National Water-Quality Assessment by the USGS)

Urban Insecticides

- Over 50% of Urban streams exceeded invertebrate toxicity benchmarks (2021)[1]
  - benchmark = concerning risk for insects
  - Imidacloprid
- Insecticides applied to garden plants come into direct contact with visiting pollinators
  - Often times applied at higher rates than ag
  - These foliar applications can be highly lethal

1) Nowell, Lisa H. et al. 2021. "Is There an Urban Pesticide Signature? Urban Streams in Five U.S. Regions Share Common Dissolved-Phase Pesticides but Differ in Predicted Aquatic Toxicity." Science of The Total Environment 793 (November 1, 2021): 148453. https://doi.org/10.1016/j.scitotenv.2021.148453.

Impacts on Pollinators

- Only 1% of insects are considered pests[1]
  - In North America
- Discussed lethal effects
  - Convulsions, paralysis, death
    - Especially for foliar appliaction
- Neonics: current concern is non-lethal or **sublethal effects**
  - From systemic application; seed treatments
- Smaller bees may be at higher risk than larger bees[1]
  - Puts many native, solitary bees at higher risk than honey bees

1) Hopwood et al. 2016. "How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees".

Neonics: Sublethal Effects on Pollinators

1

- Lower population levels
- Esp. smaller species[2]
- Slows larvae development
- Lowers larvae weight and size

3

- Reproduction
- Slower maturation
- Higher mortality rate

3

- Food consumption
- Reproduction
- Foraging activity
- Lower worker survival
- Lower queen production

3

- Flight
- Navigation
- Slower learning
- Pupa survival
- Reduced taste/smell

1) Pecenka, Jacob R., and Jonathan G. Lundgren. "Non-Target Effects of Clothianidin on Monarch Butterflies." The Science of Nature 102, no. 3–4 (April 2015): 19. https://doi.org/10.1007/s00114-015-1270-y.
2) Forister et al. "Increasing Neonicotinoid Use and the Declining Butterfly Fauna of Lowland California." Biology Letters 12, no. 8 (August 31, 2016): 20160475. https://doi.org/10.1098/rsbl.2016.0475.
3) Hopwood et al. 2016. "How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees".

Worst Neonics for Pollinators

Insect Group:	Butterflies[1,2]	Native Bees[3]	Bumble Bees[3]	Honey Bees[3]
Highly Toxic[3] (< 2ug = LD50) According to EPA	(monarchs) Clothianidin* Imidacloprid*	Clothianidin Imidacloprid	Imidacloprid Clothianidin Dinotefuran Thiamethoxam	Clothianidin Dinotefuran Imidacloprid Thiamethoxam

*Studies vary.
May depend on host plant

1) Pecenka, Jacob R., and Jonathan G. Lundgren. "Non-Target Effects of Clothianidin on Monarch Butterflies." The Science of Nature 102, no. 3–4 (April 2015): 19. https://doi.org/10.1007/s00114-015-1270-y.
2) Forister et al. "Increasing Neonicotinoid Use and the Declining Butterfly Fauna of Lowland California." Biology Letters 12, no. 8 (August 31, 2016): 20160475. https://doi.org/10.1098/rsbl.2016.0475.
3) Hopwood et al. 2016. "How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees".

Worst Neonics for Pollinators

Insecticide	Brand Name	Setting Used	Sold by:	Persistent?
Clothianidin	Poncho, Belay	Ag and Home	Bayer	Yes
Imidacloprid	Admire, Marathon, Macho	Ag and Home	Bayer	Yes
Dinotefuran	Venom, Safari, Scorpion	Ag and Home	Mitsui Chemicals	Not proven
Thiamethoxam	Cruiser, Platinum	Ag and Home	Syngenta	Yes

https://nevegetable.org/insecticides-alphabetical-listing-trade-name

Pesticide Companies: The Big Four

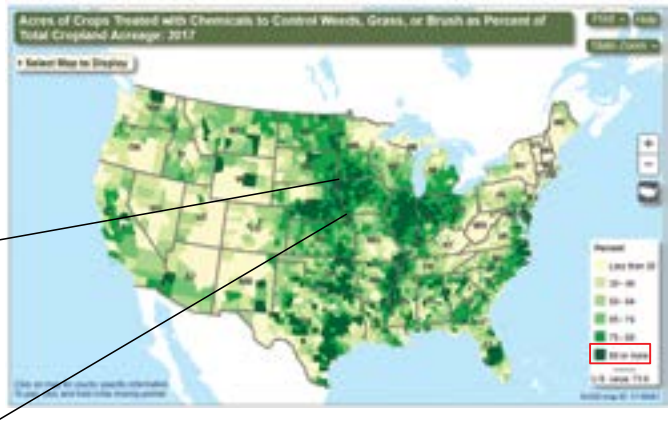
- Largest agricultural seed and chemical sellers:
  - 2015
  1) Syngenta
  2) Bayer
  3) BASF
  4) Dow
  5) Monsanto
  6) DuPont
- After mergers:
  - BASF
  - Bayer (Monsanto)
  - Dow-DuPont
  - Syngenta

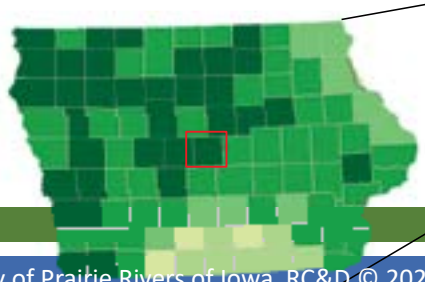
2015 sales ($ millions)		# of products sold		
Company	Country	Seeds and traits	Agricultural chemicals	Merger partner
BASF	Germany	Small	6,455	None
Bayer	Germany	1,416	9,173	Monsanto
Dow Chemical	U.S.	1,409	4,977	DuPont
DuPont	U.S.	6,785	3,013	Dow
Monsanto	U.S.	10,243	4,758	Bayer
Syngenta	Switzerland	2,838	10,005	ChemChina

MacDonald, James M. "Mergers in Seeds and Agricultural Chemicals: What Happened?" Economic Research Service, USDA, February 15, 2019. https://www.ers.usda.gov/amber-waves/2019/february/mergers-in-seeds-and-agricultural-chemicals-what-happened/.

Impacts of Herbicides

- Honey bees: glyphosate[1]
  - Lower weight
  - Slower development
  - Alters gut bacteria
- Inactive ingredients, or "Inert" are unregulated and may pose more risks to bee and human health





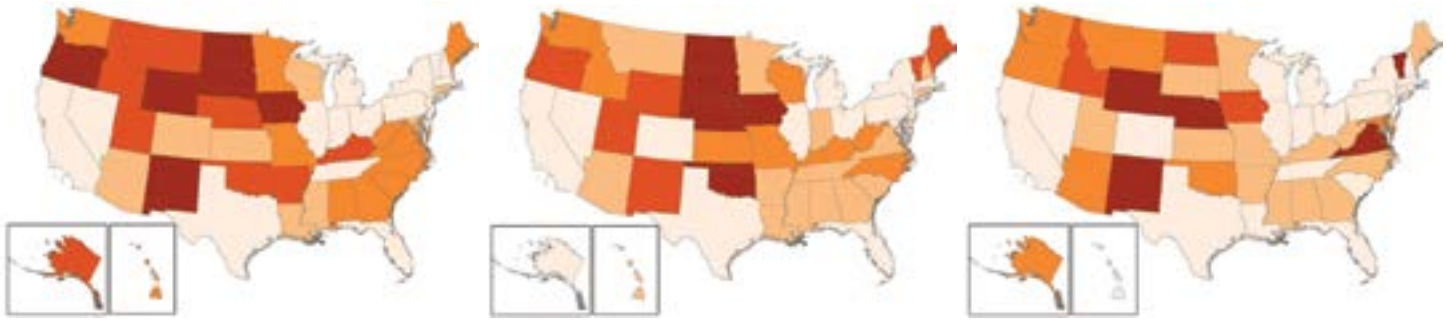
90.51%
1.2x US avg

1) Dai et al. 2018. "The Herbicide Glyphosate Negatively Affects Midgut Bacterial Communities and Survival of Honey Bee during Larvae Reared in Vitro." *Journal of Agricultural and Food Chemistry* 66, no. 29 (July 25, 2018): 7786–93. https://doi.org/10.1021/acs.jafc.8b02212.

Ag Census Web Maps, USDA, National Agricultural Statistics Service. Last Updated: Aug 27, 2020

Impacts on Humans: work-related poisonings by state and year

2011 2012 2013



Acute work-related pesticide poisoning rates per 100,000 employed persons 16 years or older, 2013

< 1.85 | 1.86 – 2.45 | 2.46 – 2.93 | 2.94 – 3.88 | > 3.89

Rate = $\frac{\text{\# acute injuries reported to poison control centers}}{\text{\# exposed to pesticides through employment}}$

"Pesticide Poisoning Rates by State | NIOSH | CDC," April 28, 2022. Center for Disease Control. https://www.cdc.gov/niosh/topics/pesticides/animatedmap.html.

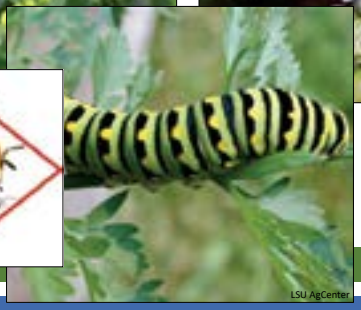
Impacts on Humans: Chronic Exposure[1]

- Inconsistent **links** to sublethal effects on children:
  - Exposure from home or working parent:
    - Wheezing
    - Lower IQ testing
    - ADHD/ADD
- **Consistent** links to sublethal effects on adults
  - Pesticide applicators and farmers
    - Wheeze
    - Asthma
- 61% of health care workers don't feel comfortable answering patient questions about pesticides
  - In heavily-farmed areas with high pesticide use

1) As reviewed by: Roberts, James R., and Catherine J. Karr. 2012. "Pesticide Exposure in Children." Pediatrics 130, no. 6 (December 2012): e1765–88. https://doi.org/10.1542/peds.2012-2758.

Reducing Pesticides

- Promote IPM management[1]
  - Utilize free "insecticides" provided by other insects
  - Use chemicals with lower persistence
- Some ideas to get discussion started:
  - Some bugs = healthy yard/garden/IPM system
  - Spray at night to avoid bee exposure
  - Native habitats need fewer/no pesticides



1) Hopwood, Jennifer, Aimee Code, Mace Vaughan, David Biddinger, Matthew Shepherd, Scott Hoffman Black, Eric Lee-Mäder, and Celeste Mazzacano. "How Neonicotinoids Can Kill Bees: The Science Behind the Role These Insecticides Play in Harming Bees," 2016.

Pathogens and Pollinators

This presentation was given on June 28, 2022. It maps out the spread of pathogens between native and nonnative bees and butterflies, summarizes the devastating impacts of some of the most concerning diseases, and addresses how to mitigate contributing factors that make native pollinators more susceptible to disease.

PRAIRIE RIVERS of Iowa

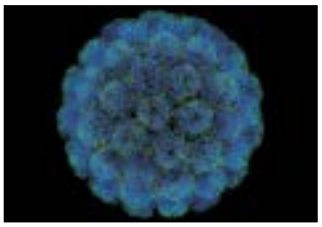
Pathogens and Pollinators

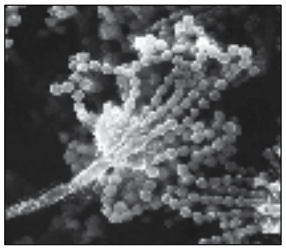
PRAIRIE RIVERS of Iowa

JESSICA BUTTERS

What's a pathogen?

- Microorganisms
  - Virus, bacteria, or fungi
- Spread by:
  - Parasites
    - Mites
    - kleptoparasites
  - Contaminated nest/pollen
  - Insect-to-insect contact
  - Through floral visitation
  - Pests





https://ento.psu.edu/research/centers/pollinators/resources-and-outreach/disappearing-pollinators/pathogens

What about pathogens?

Bombus terrestris – native to UK

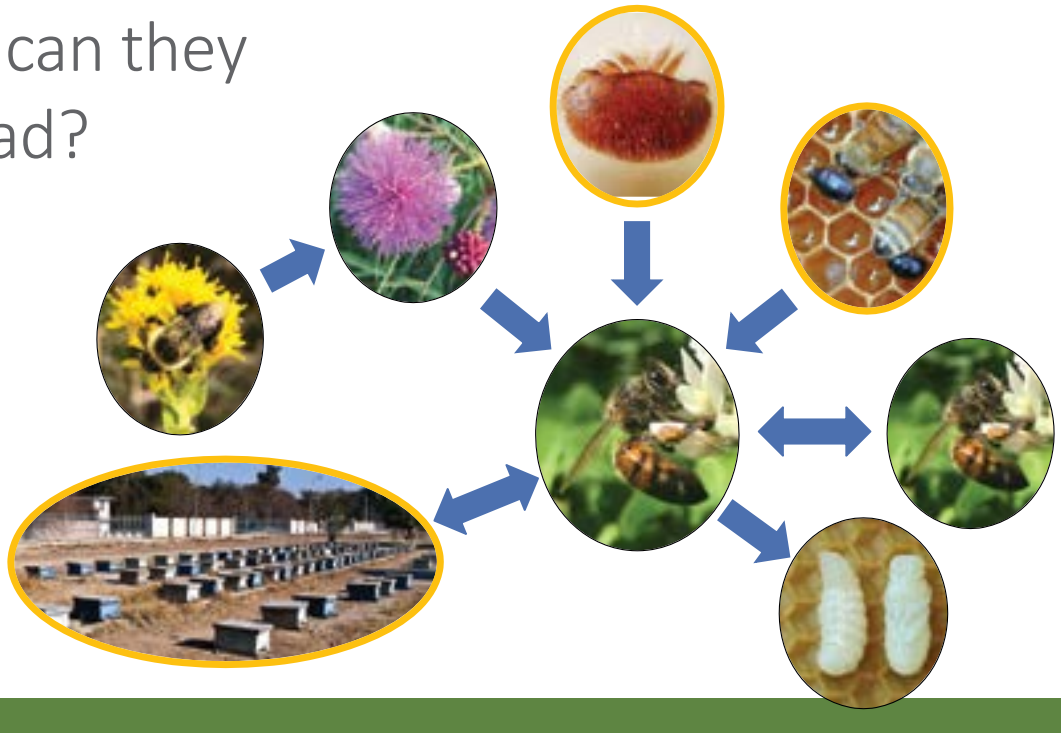
- Situation similar to humans
  - Always small amount present
  - High replication = more of an issue
  - Lethal and nonlethal effects
    - Depends on pathogen level (# replications)

1) How do they spread?
2) What pathogens are of highest concern?
3) How do we mitigate pathogen spread?

How can they Spread?

1) Grozinger, Christina M., and Michelle L. Flenniken. "Bee Viruses: Ecology, Pathogenicity, and Impacts." *Annual Review of Entomology* 64, no. 1 (January 7, 2019): 205–26. https://doi.org/10.1146/annurev-ento-011118-111942.

How can they Spread?



1) Grozinger, Christina M., and Michelle L. Flenniken. "Bee Viruses: Ecology, Pathogenicity, and Impacts." *Annual Review of Entomology* 64, no. 1 (January 7, 2019): 205–26. https://doi.org/10.1146/annurev-ento-011118-111942.

Impact of Pathogens

Cilia, G., Zavatta, L., Ranalli, R., Nanetti, A., & Bortolotti, L. (2021). Replicative Deformed Wing Virus Found in the Head of Adults from Symptomatic Commercial Bumblebee (Bombus terrestris) Colonies. *Veterinary Sciences*, *8*(7), 117. https://doi.org/10.3390/vetsci8070117

- Weakens immunity
- Deformity
- Paralysis
- Death/Colony collapse
- Slows larval development
- Lowers weight/size of adults/larvae
- Lower foraging/flight ability

1) Grozinger, Christina M., and Michelle L. Flenniken. "Bee Viruses: Ecology, Pathogenicity, and Impacts." *Annual Review of Entomology* 64, no. 1 (January 7, 2019): 205–26. https://doi.org/10.1146/annurev-ento-011118-111942.

Honey Bees

- Deformed wing virus (DWV)[1]
  - Found in 20 bee species
  - Impacts honey and bumble bees
  - Many forms/variants
- Other diseases
  - Nosema fungi (links to CCD)
  - Chalkbrood (*Ascosphaera*)
  - Black queen cell virus (honey and bumble)
  - Sacbrood virus (SBV)
  - Paralysis viruses
    - (IAPV), (ABPV), (SBPV)
- Bees and plants can share viruses as well
  - tobacco ringspot virus

1) Grozinger, Christina M., and Michelle L. Flenniken. "Bee Viruses: Ecology, Pathogenicity, and Impacts." *Annual Review of Entomology* 64, no. 1 (January 7, 2019): 205–26. https://doi.org/10.1146/annurev-ento-011118-111942.

Bumble Bees

- *Nosema bombi*
  - Fungus; links to declining bumble bee species
  - Lowers reproduction and worker survival rates
- *Crithidia bombi*[1]
  - Protozoan
  - Spread from managed to wild bumble bees
    - Higher prevalence found near greenhouses
  - Rise in pathogens parallel with pop. declines[2]
  - Causes 40% decrease in successful foundresses
  - Reduces size of colonies
- Tracheal mites
  - High numbers may reduce lifespan[3]
- Deformed wing virus new threat

1) M. Berenbaum et al. National Academies of Sciences, Engineering, and Medicine. 2007. Status of Pollinators in North America. Washington, DC: The National Academies Press. https://doi.org/10.17226/11761. https://nap.nationalacademies.org/read/11761/chapter/3
2) Cameron, Sydney A., Haw Chuan Lim, Jeffrey D. Lozier, Michelle A. Duennes, and Robbin Thorp. "Test of the Invasive Pathogen Hypothesis of Bumble Bee Decline in North America." Proceedings of the National Academy of Sciences 113, no. 16 (April 19, 2016): 4386–91. https://doi.org/10.1073/pnas.1525266113.
3) Otterstatter, Michael Christopher, and Troy Lorne Whidden. "Patterns of Parasitism by Tracheal Mites (Locustacarus Buchneri) in Natural Bumble Bee Populations." *Apidologie* 35, no. 4 (July 1, 2004): 351–57. https://doi.org/10.1051/apido:2004024.

Native Bees (non-*Bombus*)

- Fungi better studied:
  - *Ascosphaera* (chalkbrood)
  - Social and managed species more at risk
  - *Osmia* species
  - High nesting densities
  - Utilize bee hotels
- Nest parasites vector diseases as well
  - Bring in diseases and mites

Butterflies

- Most studies focus on viruses as pesticides
  - Gypsy moth; US Forest Service
  - Baculoviruses; "Gypcheck" – as recently as 2009
    - Highly specific: genus or species level
    - Gypcheck is species-specific thus far
- Nuclear polyhedrosis virus – "Black Death"
  - Ingesting, mating, egg-laying
- *Ophryocystis elektroscirrha* (OE)

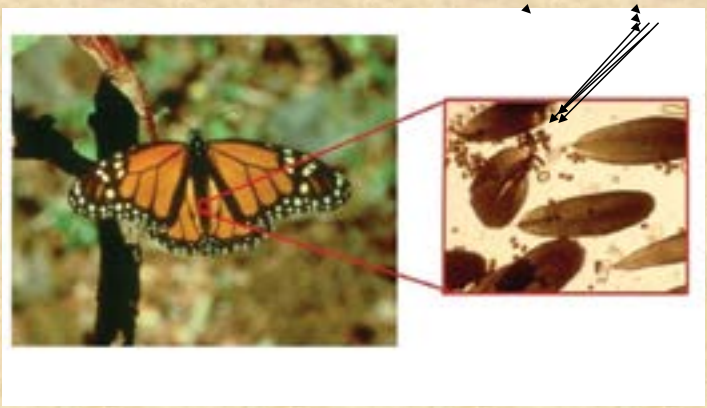
1) Grozinger, Christina M., and Michelle L. Flenniken. "Bee Viruses: Ecology, Pathogenicity, and Impacts." *Annual Review of Entomology* 64, no. 1 (January 7, 2019): 205–26. https://doi.org/10.1146/annurev-ento-011118-111942.
2) Colla, Sheila R., Michael C. Otterstatter, Robert J. Gegear, and James D. Thomson. "Plight of the Bumble Bee: Pathogen Spillover from Commercial to Wild Populations." *Biological Conservation* 129, no. 4 (May 2006): 461–67. https://doi.org/10.1016/j.biocon.2005.11.013.

Biology and life cycle of OE

Dr. John Pleasants

What is OE?

- *Ophryocystis elektroscirrha (*OE)
- Protozoan parasite that infects monarch and queen butterflies



What is OE?

- Protozoans: single celled organisms
- Share many characteristics with animals (often called animal-like protists)

Euglena

Paramecium

Plasmodium

Obligate parasite: must live within a host to grow and multiply.

- Monarch and queen butterflies are the only known hosts of OE

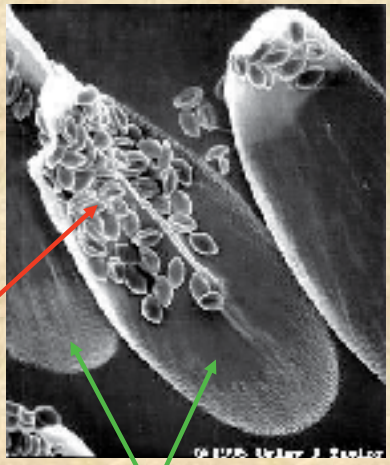
Monarch Butterfly (*Danaus plexippus*)

Queen Butterfly (*Danaus gilippus*)

OE produces spores on the outside of monarchs

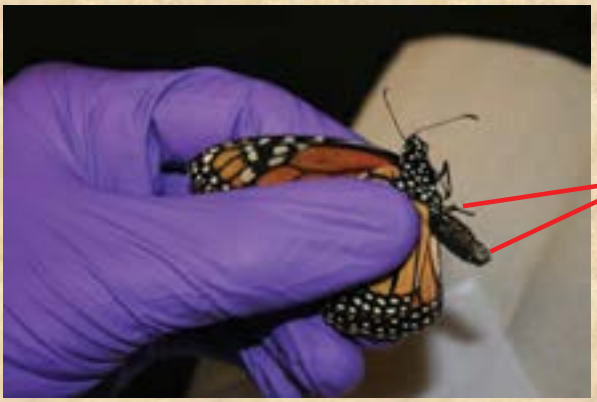
- Spores: dormant cells that can resist harsh environmental conditions
- Found on the outside of infected monarchs

Highly Magnified Image



OE Spores

- Greatest concentration of OE spores is on the abdomens of infected monarchs



OE Spores

- Spores appear as small, brown or black lemon-shaped objects.

OE Life Cycle

- OE can only reproduce inside living monarchs
- Infected females pass the parasite to their offspring when they lay eggs
- Dormant spores on the outside of the female's abdomen are scattered on the eggs and milkweed leaves

Infected females lay eggs and scatter OE spores on eggs and leaves

Dark spots are OE spores

OE Infects the Caterpillar

- When a caterpillar emerges, its first meal is the egg shell
- It ingests OE spores along with the shell and milkweed

Newly emerged caterpillar

A caterpillar eating the egg shell and any OE spores on the shell's surface

OE Moves to the Midgut

- The dormant spores move through the larva to the midgut
- Digestive chemicals break open the spores releasing the parasites
- The parasites then pass through the intestinal wall to the hypoderm (underneath caterpillar's skin)

OE Reproduces in the Pupa

- Most damage to the butterfly happens during the pupal stage
  - Where OE reproduces asexually
  - Each OE parent cell divides many times, greatly increasing the number of parasites
- The OE parasite then goes through sexual reproduction, followed immediately by meiosis

Spores Form in the Pupae

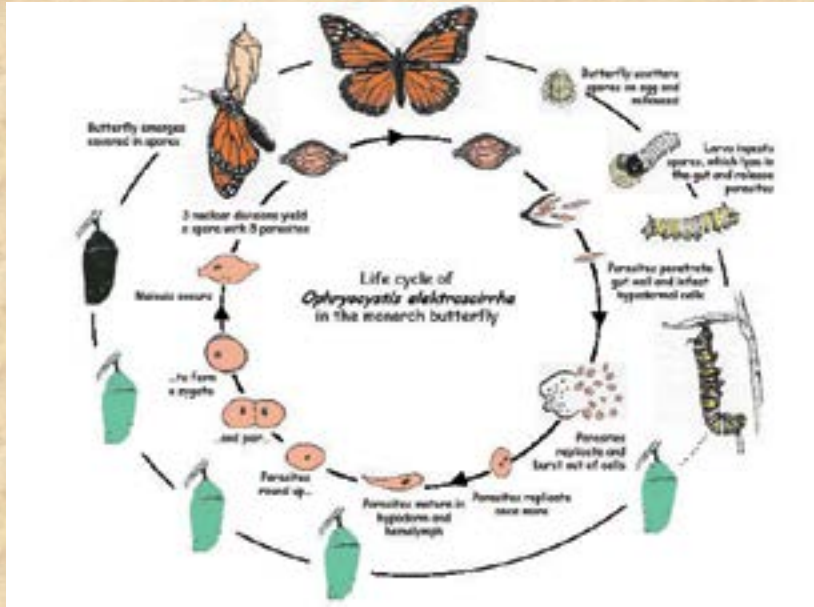
- About three days before the adult emerges from the pupa, OE spores begin to form
- Spores allow OE to survive outside of the monarch's body
- The spores can be seen through the integument or outside layer of the pupa

OE Spores

Adult Emerges with Spores

- Infected adults emerge covered with spores
  - *Once butterflies are infected, they do not recover*
  - By the time adults emerge with parasite spores, all physical damage by the OE parasites has been done
  - The parasites do not grow or reproduce on the adults
  - The spores are inactive or dormant until they are eaten by another caterpillar

Life cycle of OE is closely related to the life cycle of the monarch butterfly.



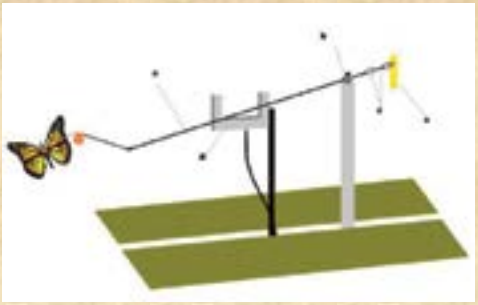
Parasitized emerging monarchs

- Monarchs that are heavily infected with OE can have difficulty emerging from their pupal cases

Infected monarchs are covered with millions of tiny OE spores

Parasite infection hinders monarch flight ability

- Studies have shown that monarchs infected with OE can not fly as far or as long as healthy butterflies



Flight mill

A flight mill is used to measure a monarch's flight endurance

How common is OE in North America?

1. Eastern migratory population
   - Less than 10% heavily infected

2. Western migratory population
   - 30% heavily infected

3. South Florida resident population
   - Over 70% heavily infected

4. Overwintering population
   - less than 7% heavily infected

Concerns about rearing butterflies

- Check for infected butterflies (scotch tape)
- Clean all rearing cages and keep butterflies apart

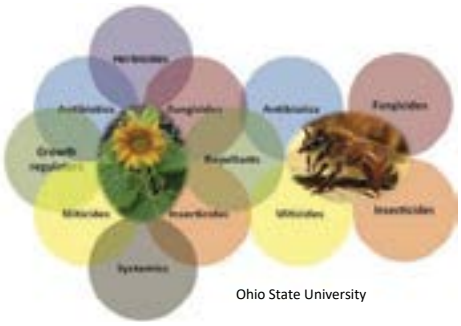
Risk Factors

- High stress
  - Pesticides
  - Poor nutrition
- Season[1]
  - Varroa mites more active in fall
    - Can't attach to native bees, but increases virus presence[2]
    - Honey bees can spread viruses to fall-foraging bees like bumble bee queens

1) Grozinger, Christina M., and Michelle L. Flenniken. "Bee Viruses: Ecology, Pathogenicity, and Impacts." *Annual Review of Entomology* 64, no. 1 (January 7, 2019): 205–26. https://doi.org/10.1146/annurev-ento-011118-111942.
2) https://phys.org/news/2019-06-honeybee-mite-bumblebee-virus.html

Pesticides and Pathogens

- Increase stress
- Insecticides
  - Increase virus-related mortality
  - Fungi/viruses sometimes used as insecticide
    - May increase risk of host-jumping
- Herbicides
  - Decrease floral resources
    - Leads to poor diet
    - Lowers immune system abilities



Ohio State University

Pathogens of highest concern

- Deformed wing virus
  - Bumble bees
- *Nosema bombi*
  - Bumble bees
- *Ophryocystis elektroscirrha*
  - Spreading to wild monarch populations
- Fungi from gregarious nesting
  - Native bees; managed or hotel-utilizers

Can habitat implementation increase pathogen presence?

- Preliminary findings of high pathogen presence in pollinator habitat intensification projects
- Does increased habitat = increased pathogens?
  - Other factors probably more pertinent[1]
  - Need to meet floral resource needs to fight pathogens[2]
- It may depend on what you plant[3]
  - Some plants may transmit pathogens more than others
  - Some plants may offer anti-microbial benefits

1) Levenson, Hannah K., and David R. Tarpy. "Effects of Planted Pollinator Habitat on Pathogen Prevalence and Interspecific Detection between Bee Species." *Scientific Reports* 12, no. 1 (December 2022): 7806. https://doi.org/10.1038/s41598-022-11734-3.
2) Conroy, Taylor J., Evan C. Palmer-Young, Rebecca E. Irwin, and Lynn S. Adler. "Food Limitation Affects Parasite Load and Survival of Bombus Impatiens (Hymenoptera: Apidae) Infected With Crithidia (Trypanosomatida: Trypanosomatidae)." Environmental Entomology 45, no. 5 (October 1, 2016): 1212–19. https://doi.org/10.1093/ee/nvw099.
3) Adler, Lynn S., Nicholas A. Barber, Olivia M. Biller, and Rebecca E. Irwin. "Flowering Plant Composition Shapes Pathogen Infection Intensity and Reproduction in Bumble Bee Colonies." *Proceedings of the National Academy of Sciences* 117, no. 21 (May 26, 2020): 11559–65. https://doi.org/10.1073/pnas.2000074117.

How to Mitigate Pathogens

- Keep apiaries smaller
- Don't move managed bees around
  - Especially between countries
- Do not release managed bumble bees
  - Or allow to escape
- Avoid using fungi as insecticides if bee-related
  - *Nosema* sp. used to combat locusts
- Extreme caution when releasing lab-reared butterflies[1]

1) Oberhauser, Karen, O. R. Taylor, Sonia Altizer, and Danel Vickerman. "Biology : Parasite Control : Ophryocystis Elektroscirrha." Monarch Watch. Accessed June 23, 2022. https://www.monarchwatch.org/biology/control.htm.

How to Mitigate Pathogens

- Increase pollinator species diversity
  - Has "dilution effect" on pathogens[1]
    - Reduces transmission; may benefit honey bees
- Diversify plant species available
  - Source similar species from different nurseries
- Increase wild bee disease monitoring
  - As well as parasite and carnivore monitoring
- Clean bee hotels

1) Fearon, Michelle L., and Elizabeth A. Tibbetts. "Pollinator Community Species Richness Dilutes Prevalence of Multiple Viruses within Multiple Host Species." *Ecology* 102, no. 5 (2021): e03305. https://doi.org/10.1002/ecy.3305.

Slamovits, Claudio H., Bryony a. P. Williams, and Patrick J. Keeling. "Transfer of Nosema Locustae (Microsporidia) to Antonospora Locustae n. Comb. Based on Molecular and Ultrastructural Data1." *Journal of Eukaryotic Microbiology* 51, no. 2 (2004): 207–13. https://doi.org/10.1111/j.1550-7408.2004.tb00547.x.