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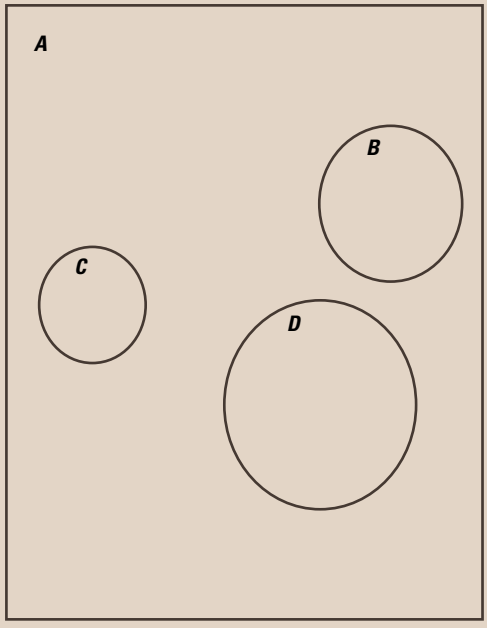
U.S. Geological Survey
Pollinator Science Strategy, 2025–35
—A Review and Look Forward

Circular 1556
Version 1.1, June 26, 2025

U.S. Department of the Interior
U.S. Geological Survey



Cover: ***A***, Photograph showing a U.S. Geological Survey (USGS) researcher collecting pollinator habitat data and photodocument on a bumblebee that was chilled before release. Photograph by Tabitha Graves, USGS. ***B***, Photograph showing a monarch butterfly (*Danaus plexippus*) on Joe Pye weed. Photograph by Emily Weiser, USGS. ***C***, Photograph showing a glacier lily (*Erythronium grandiflorum*) growing in rocky soil in Glacier National Park in Montana. Photograph by Tabitha Graves, USGS. ***D***, Photograph showing a rusty patched bumble bee (*Bombus affinis*) visiting butterfly milkweed (*Asclepias tuberosa*). Photograph by Clint Otto, USGS.

Back cover: Photograph showing USGS researchers collecting pollinator habitat data as part of a collaborative project in Glacier National Park, Montana. Photograph by Tabitha Graves, USGS.

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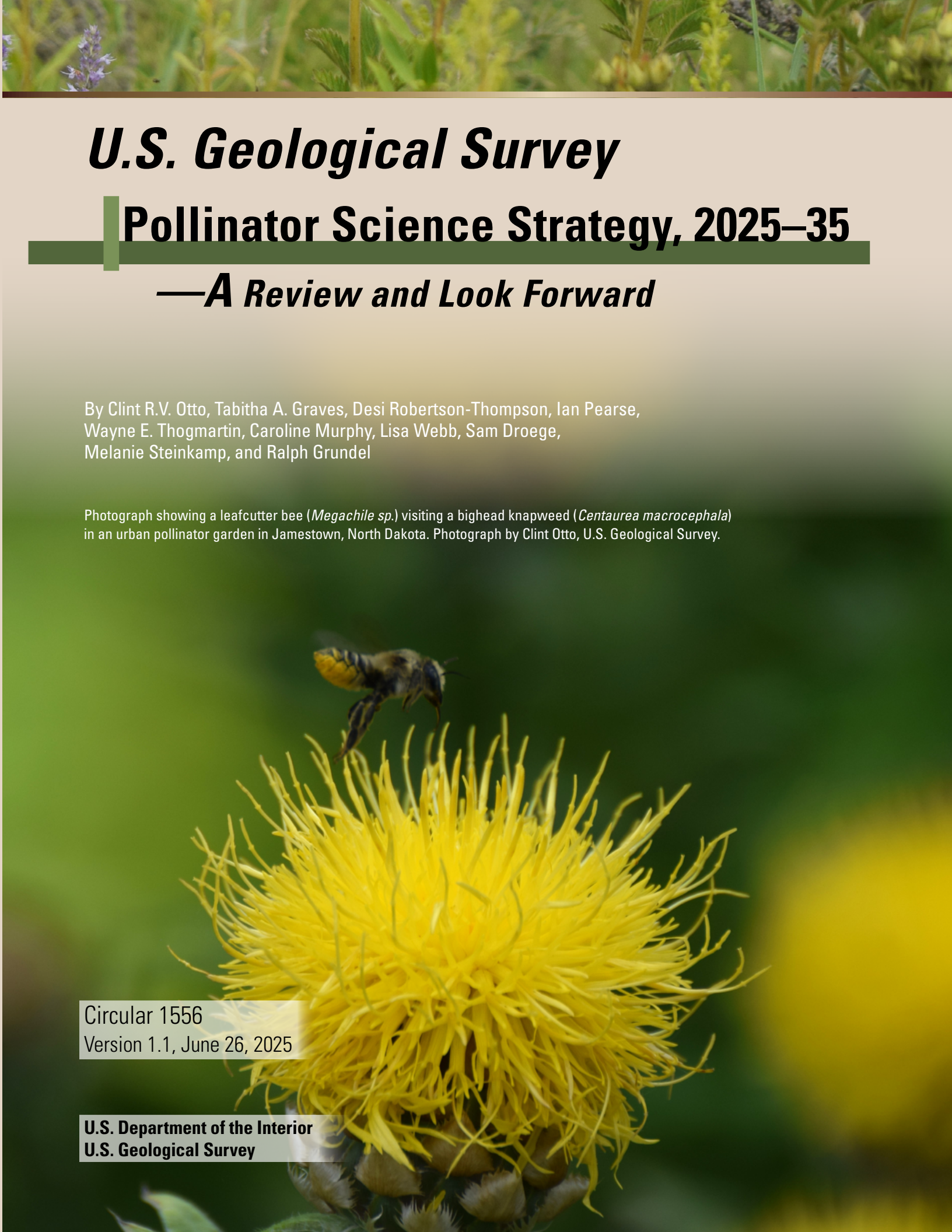
Photograph showing a leafcutter bee (*Megachile sp.*) visiting a bighead knapweed (*Centaurea macrocephala*) in an urban pollinator garden in Jamestown, North Dakota. Photograph by Clint Otto, U.S. Geological Survey.



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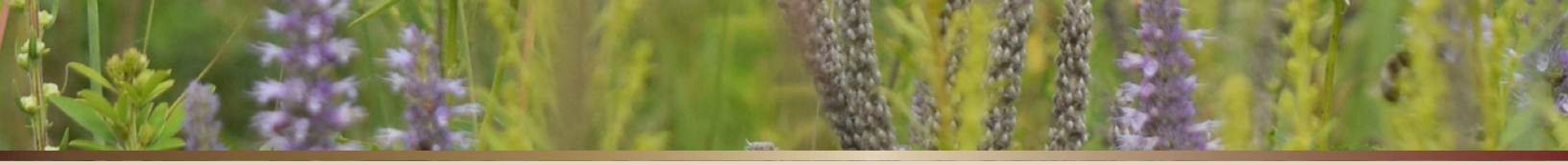

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Photograph showing a large bee of the prairies (*Andrena helianthiformis*), known as a specialist bee on sunflowers. The bee was captured in Badlands National Park, South Dakota. Photograph by Aaman Mengis, U.S. Geological Survey.

Acknowledgments

We are grateful for the thoughtful feedback and comments from U.S. Geological Survey (USGS) scientists and our partners on an earlier version of the "U.S. Geological Survey Pollinator Science Strategy, 2025–35—A Review and Look Forward." Reviews from Mark Wimer (USGS), Kathryn Thomas (USGS), Robert Cornman (USGS), Elizabeth Sellers (USGS), Hollis Woodard (University of California-Riverside), and Dan Cariveau (University of Minnesota) greatly improved the quality of this document.

Photograph showing a half-black bumblebee (*Bombus vagans*) about to land on a field thistle (*Cirsium discolor*). Photograph by Alma Schrage, U.S. Geological Survey.

Photograph showing a U.S. Geological Survey volunteer assisting with a bee monitoring project at Northern Prairie Wildlife Research Center in Jamestown, North Dakota. People of all ages and backgrounds understand the importance of pollinators in producing the foods Americans eat and the wild places they enjoy, and want to do their part to support pollinators.
Photograph by Clint Otto, U.S. Geological Survey.

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Inset: Photograph showing a metallic mason bee (*Osmia aglaia*) collected in Yosemite National Park as part of a wildland fire research project. Photograph by the USGS Bee Lab.

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Executive Summary

This "U.S. Geological Survey Pollinator Science Strategy, 2025–35—A Review and Look Forward" ("Pollinator Science Strategy") describes the science vision of the U.S. Geological Survey (USGS) to support management, conservation, and policy decisions on animal pollinators and their habitats. As the science arm of the Department of the Interior (DOI), the USGS has a primary role in providing scientific information to natural resource managers and policymakers across the United States. This "Pollinator Science Strategy" was drafted by a team of USGS pollinator researchers and was further developed through feedback from Federal, State, Tribal, nongovernmental organizations, and industry partners. This "Pollinator Science Strategy" highlights the USGS's role in the research to promote healthy pollinator populations and address partner information gaps so they can make more informed management decisions. By outlining the importance of USGS science in addressing the information needs of other agencies, organizations, and the public, the "Pollinator Science Strategy" reaffirms the USGS's commitment to pollinator research and showcases our research priorities for 2025–35.

With more than 300 research centers nationally, the USGS is equipped to address pollinator science across scales of complexity and geographic range. USGS pollinator science is organized according to the following five thematic areas:

1. Assessing species ecology, distributions, and natural history requirements.
2. Tracking species status and trends.
3. Understanding species threats and stressors.
4. Informing restoration and management actions.
5. Developing novel methods for improving pollinator research, monitoring, and population outcomes that can benefit our Nation.

Our pollinator information products and associated data are made widely available to the public to ensure scientific transparency and accessibility. This "Pollinator Science Strategy" concludes with several research goals that the USGS will work towards from 2025 to 2035, representing our vision for USGS science. These research goals include synthesizing and modernizing the latest information on pollinator threats, developing research that assists managers with habitat design and restoration, providing training to partners on native bee identification and monitoring design, and developing new technologies for assessing the status and trends of our nation's pollinators.

U.S. Geological Survey Pollinator Science Mission Statement

Pollinators are vital to the health of ecosystems and human societies. Our Pollinator Science mission is to pursue science to understand pollinator status, resource needs, and stressors in response to our country's pollinator conservation interests. We develop data, tools, models, frameworks, and natural history information, in collaboration with partners, to improve decision making for the beneficial goal of conservation and enhancement of pollinator populations.

Importance of Pollinators

Nearly 90 percent of all flowering plants depend on animal pollination services to facilitate sexual reproduction (Tong and others, 2023), having much of this service provided by bees. In a very direct sense, these pollinators are the foundation of terrestrial ecosystems across the globe. Without them, many plants would not reproduce, and the food resources they supply to humans and wildlife would vanish. Nearly all wildflowers that grow across prairies, forests, wetlands, alpine meadows, deserts, and urban areas need pollination from animal pollinators. Having diverse pollinator communities contributes to biodiversity and ecosystem function and ensures our agricultural lands and natural areas continue to support people and wildlife.

These pollinators do not just support native plants in our ecosystem; they also pollinate crops. Roughly 75 percent of all agricultural crop types depend on, or are enhanced by, animal pollination (Klein and others, 2007), demonstrating the essential link between animal pollinators and the human diet. Domesticated bees and wild bees pollinate crops such as sunflowers, cherries, blueberries, and cucumbers (Calderone, 2012) and can even increase yield of major row crops such as soybeans and cotton (de O. Milfont and others, 2013; Gagic and others, 2019). Crop pollination from bees and other animals is an ecosystem service valued at $215 billion globally and $34 billion in the United States (Vanbergen and others, 2013; Jordan and others, 2021). Although bees are responsible for most crop and wildflower pollination worldwide, several other animal groups also serve as vital pollinators (Box 1—Meet the Pollinators).

Top: Photograph showing monarch butterflies (*Danaus plexippus*) clustering in winter on the trunk of an oyamel fir (*Abies religiosa*) in Mexico. Photograph by Emily Weiser, U.S. Geological Survey.

Left: Photograph showing a National Park Service (NPS) researcher netting a bee as part of a collaborative NPS–U.S. Geological Survey project at Indiana Dunes National Park. Photograph by Tyler McGill, NPS.

Box 1. Meet the Pollinators

Pollination is the act of moving pollen grains from the male part of a flower (anther) to the female part of a flower (stigma). This action allows the male reproductive cells, formed in the pollen grain, to fertilize the female reproductive cells, leading to the creation of a seed that can develop into a new plant. The pollen can be moved in many ways. While some pollen moves by wind, the pollen of many plants relies exclusively on animals for movement. Although bees are the most widely known group of animal pollinators, other groups of insects, and even some vertebrates pollinate our wildflowers and agricultural crops (Rader and others, 2016). Insects vary in their pollination efficiency depending on the insect and plant species.

Wild Bees

There are approximately 4,000 native bee species known to occur in North America, but many species have yet to be identified (Michener, 2007). Many roles these insects have in sustaining life in ecosystems are still being discovered. Although social, colony-forming species such as bumble bees are familiar to many people, most bee species are solitary, meaning that individual females build and provision nests, often in the soil, without assistance from other bees. These bees are less apparent in the environment because of their solitary nature, often going unnoticed by people; yet they are essential for crop and wildflower pollination.

Butterflies and Moths

More than 13,000 butterfly and moth species occur in North America and many act as pollinators (Hahn and Brühl, 2016). Unlike bees, few butterflies and moths collect pollen for themselves or their young and typically lack specialized pollen collecting structures on their bodies. Nonetheless, most butterflies, and some moths, visit wildflowers to obtain nectar for energy and, in the process can transfer pollen among flowers. These butterflies and moths can pollinate flowers by a variety of mechanisms, including transferring pollen via electrostatic charge accumulated during flight (England and Robert, 2024) and some have specialized pollination roles, such as moths that pollinate night-blooming flowers. Notable examples of flowers, such as on Joshua trees and other yucca-type plants, native azaleas, lilies, and orchids, are exclusively pollinated by butterflies and moths.

Other Notable Insect Pollinators

Although often overlooked as important pollinators, many species of flies, beetles, ants, and wasps are the primary pollinators in some ecosystems (that is, the Arctic) or plant groups (for example, beetles on magnolias). Many of these insects only consume nectar but carry pollen on their bodies as they navigate from flower to flower, thereby facilitating pollination. Flies are the most frequently observed non-bee insect group on these crops. Per individual, non-bee insects may be inefficient at pollinating crops and wildflowers, yet the high frequency at which they visit flowers contributes to the pollination service they provide (Rader and others, 2016).

Vertebrate Pollinators

Hummingbirds in North America pollinate several species of flowering plants. They use their slender bill and long tongue to drink nectar from flowers. During their frequent flower visits, pollen inadvertently deposited on their bill, can then be transferred to other plants. Hummingbirds are frequent visitors of flowers, providing many opportunities for pollen transfer among flowers. Other notable examples of birds as pollinators include the *Zenaida asiatica* (Linnaeus, 1758; white-winged dove) and the *Fringillidae* (Leach, 1820; Hawaiian honeycreepers). Bats are also an essential vertebrate pollinator and are a primary pollinator of the iconic *Carnegiea gigantea* (saguaro cactus) of the Southwest. Other agave and cactus species are also pollinated by bats.

Need for Pollinator Science

Increased understanding of the key role of pollinators in ecosystem health and agricultural crop production highlights the need for effective pollinator science in the United States. Research is needed to assess pollinator population trends accurately, understand how environmental stressors, such as lack of floral resources, and management actions, such as habitat restorations, affect pollinators. The USGS serves the research needs of agencies in the Department of the Interior (DOI) and conducts collaborative research with other science agencies and departments. The Bureau of Land Management (2022) has a pollinator management plan that specifies the need for pollinator research to support management decisions, and the U.S. Fish and Wildlife Service (FWS) has created a Center for Pollinator Conservation whose mission includes supporting pollinator conservation (https://www.fws.gov/program/center-pollinator-conservation). Numerous Tribal (for example, Tribal Alliance for Pollinators, https://www.ebflearningcenter.org/tribal-alliance-for-pollinators), State-focused (for example, Iowa Pollinator Working Group), and regional (for example, Mid-America Monarch Conservation Strategy | MAFWA) groups request scientific information to inform management actions and to support pollinator conservation. An aspirational goal of USGS pollinator research is to inform management such that species declines, and extinction risk are prevented or reduced.

Although many organizations benefit from pollinator research, the Federal Government can take a leadership role in coordination and in assuring broad coverage and applicability of research towards achieving national goals for pollinator health (Pollinator Health Task Force, 2015). For the USGS, contributions to that leadership role include identifying key needs for research and interacting with other researchers and users of research to ensure that the USGS science complements, rather than duplicates, other research efforts. For example, the U.S. Department of Agriculture (USDA) researches pollinators (Agricultural Research Service [ARS]). The USGS supports this research, which is largely focused on supporting agricultural systems and crop producers (USDA, 2022). Previous collaborations between the USGS and USDA have identified cost-effective seed mix designs to enhance private-land programs supported in the U.S. Farm Bill (Simanonok and others, 2022). Some USGS research focuses on questions about pollinators on rangeland, where flowering plants support cattle and deer, and invasive species on Federal lands, which threaten livelihoods and wildlife.

Despite what the scientific community currently knows about the biology of a few well-known pollinators, considerable knowledge gaps still exist for most native pollinator groups. The most studied pollinator is *Apis mellifera* (Linnaeus, 1761; European honey bee), introduced to North America for its pollination of crop plants and production of honey and wax (Marcelino and others, 2022). However, much less is known about most of the other pollinators in the United States, such as native bees, butterflies, moths, other insects, birds, and bats (Box 1—Meet the Pollinators). Pollinator science is needed to inform status assessments, understand ecological threats, and better manage a wider variety of pollinator species. Addressing these scientific needs will help keep common pollinators common and improve the vitality of declining species, thereby preventing or reducing regulation. Addressing these needs also supports land management goals to provide healthy landscapes resilient to invasive species, drought, and other stressors and to support wildlife and agriculture that depend on pollinators.

U.S. Geological Survey Role in Pollinator Science

The USGS provides the science needed to support pollinator conservation interests of, and benefits to, the public and our Federal, State, Tribal, nongovernment organizations (NGO) and industry partners. The USGS is equipped to address pollinator science information needs, whether National or local, of our partners (for example, Kearns & West, 2025). Some recent work by the USGS includes the following:

- Developing efficient, robust techniques and sample designs for large-scale status assessments.
- Informing recovery efforts of at-risk pollinators.
- Developing collaborative frameworks to improve and evaluate the effectiveness of conservation actions.
- Informing land-use decisions related to agriculture and energy development.
- Understanding the role of pollinators in supporting ecosystem goods and services.

Structure and Programs

The USGS employs thousands of scientists and support staff across more than 300 locations nationwide. USGS scientists have widely recognized skills and expertise across fields including taxonomy, ecology, chemistry, molecular biology, remote sensing, risk assessments, and decision support that enable the USGS to perform comprehensive and interdisciplinary research activities to address current and evolving pollinator science needs (refer to the "U.S. Geological Survey Pollinator Science Themes" section). Researchers at USGS science centers, research stations, and labs engage in a wide range of pollinator research. Some research stations reside within or near national parks, wildlife refuges, and other public lands, providing outdoor laboratories

that allow researchers to focus efforts within specific landscapes under more environmentally relevant conditions. The USGS Cooperative Fish and Wildlife Research Units and centers collaborate with universities, Federal and State agencies, and Tribes to perform applied pollinator research and train pollinator ecologists. The USGS National and Regional Climate Adaptation Science Centers (CASCs) provide insight into how climate change affects pollinators and their habitats. By partnering scientists with natural and cultural resource managers and local communities, CASCs develop tools and strategies to help pollinators and their habitats adapt to a changing climate. The USGS Earth Resources Observation and Science Center develops innovative land-change data products and Landsat satellite imagery. These remotely sensed data products are routinely used by researchers and policy decisionmakers across the Nation and world to solve pollinator conservation problems (for example, Monarch Conservation Planning Tools) and mapping where bee pollination services are most needed to support agriculture (for examples, refer to Koh and others, 2016).

Alignment with Department of the Interior and U.S. Geological Survey Missions, Goals, and Strategies

The USGS works extensively with partners to respond to the research priorities outlined in the Federal "Pollinator Research Action Plan" (Pollinator Health Task Force, 2015). For example, by creating identification tools and keys, providing taxonomic training, and exploring new technologies, including photo-identification and environmental deoxyribonucleic acid (eDNA), the USGS has expanded capacity to accurately identify target species for research, monitoring, and community engagement. Researchers at the USGS are also working to understand the qualities of habitats and landscapes that support pollinators, assess environmental stressors, develop decision-support tools and best management practices for pollinators and their habitats. These research efforts support information needs identified by multiple Federal agencies, such as the FWS's "Pollinator Action Plan" (Kearns & West, 2025) and the Bureau of Land Management's "Strategic Plan for Pollinator Conservation."

Our pollinator research is performed in alignment with the "U.S. Geological Survey 21st-Century Science Strategy 2020–2030" (U.S. Geological Survey, 2021), which emphasizes the role of USGS in integrating biological, geospatial, and other data to support partner information needs.

Data Integrity and Accessibility

The USGS strives to provide scientific leadership by delivering and curating high-quality science and promoting data integrity and accessibility to the public. By leveraging the USGS ScienceBase, a robust data management and sharing platform, the USGS provides open access to high-quality, meticulously curated datasets, thereby facilitating transparency and fostering a collaborative research environment. Additionally, adherence to the USGS Fundamental Science Practices and "The Findable, Accessible, Interoperable, and Reusable (FAIR) Principles for Scientific Data Management and Stewardship" (Wilkinson and others, 2016) ensures the reliability, reproducibility, and integrity of scientific data and methods. By making data readily available to scientists, policymakers, and the public, USGS empowers stakeholders to make informed decisions, understand the basis of our scientific conclusions, and encourages the advancement of sound pollinator science. The USGS also hosts and maintains the Integrated Taxonomic Information System (ITIS; www.itis.gov), which is the internationally recognized source for authoritative information on species names and their hierarchical classification. As such, the ITIS database is fundamental to the description, conservation, and management of pollinator species. The USGS also manages the US node to the Global Biological Information Facility (GBIF), which is the largest open repository of species occurrence data in the world and is a premier source of information on species distribution for animals, including pollinators, and plants.

Right: Photograph showing a U.S. Geological Survey (USGS) and National Park Service (NPS) researcher collecting habitat data as part of a collaborative NPS–USGS pollinator research project at Indiana Dunes National Park. Photograph by Tyler McGill, NPS.

U.S. Geological Survey Pollinator Science Themes

In the USGS, pollinator research primarily operates within the Ecosystems Mission Area, the biological research arm of the DOI. Much of USGS pollinator research can be represented by five thematic areas (listed below) that are in alignment with Ecosystems Mission Area research themes. In many cases, individual research projects range across thematic areas, underscoring the scope and complexity of our science and the importance of an integrated approach. As with all USGS science, our pollinator information products and associated data are made widely available to the public to help ensure scientific transparency and accessibility. Our science is used by natural resource managers and decision-makers to better conserve pollinators and their habitats. The five thematic areas of the USGS pollinator research include:

1. *Ecology, Distributions, and Natural History*.—Surprisingly little is known about the ecology, floral needs, distribution, and habitat requirements of many of the animal pollinators that support our functioning ecosystems and pollinate our crops, ensuring food security. USGS scientists systematically study pollinators to understand how they interact with their environment and with other species. Our research ranges from the scale of the individual organism to the ecosystem, with emphasis on insect taxonomy, species distribution patterns, population ecology, community ecology, and life history. The USGS undertakes fundamental studies aimed at closing knowledge gaps, so land managers know better how to manage resources with pollinators in mind. By understanding and protecting the complex connections between pollinators and ecosystems, we can better inform conservation strategies and promote ecosystem resilience in the face of increasing natural and anthropogenic environmental stressors.

2. *Inventory and Trends*.—One of the primary, global needs for pollinator science is understanding distribution patterns and population trends. The USGS is assisting partners in the development of multiple pollinator monitoring programs across the United States to help understand where the need for conservation action might be the greatest. We also provide technical assistance in the analysis of complex monitoring datasets so that the status and trends of pollinators can be quantified. Successful inventory and population assessments of pollinators require accurate identification, particularly for bees. To that end, USGS scientists are also developing publicly available tools and resources for training partners and the American public on how to identify and survey native bees. Effective monitoring helps to prevent species decline, thereby reducing regulation, and aiding in recovery of species of conservation concern.

3. *Threats and Stressors*.—The USGS motto is “Science for a changing world.” The USGS provides national leadership in understanding how environmental stressors such as land-use change, invasive plants and animals, pesticide use, and drought can affect pollinator populations. Our science identifies opportunities to reduce conflicts between wildlife and energy development. USGS pollinator science is used by partners to inform recovery efforts of species of conservation concern. These foci are part of a general program to improve the scientific basis for managing resources effectively for all pollinators across a wide variety of cross-jurisdictional landscapes, thereby preventing species decline and informing efforts to restore species.

4. *Conservation, Restoration, and Management*.—Conserving insects, other pollinators, and their habitats requires scientifically based management decisions. Answering the “how” and “where” management questions can be challenging. The USGS undertakes studies to understand how the ecological benefits of pollinator habitat can be maximized and to understand where the needs for pollinator conservation, restoration, and enhancement might be the greatest. USGS research is being used by our partners to improve the effectiveness of land management and inform restoration efforts of millions of acres of land across the United States.

5. *Methods Development*.—USGS scientists develop new methods and methodological approaches and improve existing methods that are used by other scientists studying pollinators. We design, develop, and test innovative methods for field and laboratory applications, analytical techniques for data analysis, and tool development for decision makers. USGS is developing novel ways to monitor pollinator species, including nonlethal sampling techniques such as eDNA collection and analysis, and evaluating pesticide-exposure risk of interest to DOI partners. We work with partners to assist with the implementation of new methods into native pollinator inventorying and population assessments, providing guidance on how these methods can be properly applied to inform conservation actions.

U.S. Geological Survey Partner Science

With a science mission to support information needs of the Department of the Interior and the American public, the USGS completes pollinator research to assist natural resource managers and policymakers in their decision making across a broad range of topics including how common management actions, such as planting or application of fire, affect pollinators, crafting recovery goals for species of special conservation concern, and tracking species and habitat status and trends. The USGS is a leader in providing remote sensed data and analytical tools for understanding landscape change (USGS EROS). The USGS collaborates with partners to create a network of science, operating from local to global scales. The USGS has helped create national frameworks to address information needs for specific species, such as for *Danaus plexippus* (Linnaeus, 1758; monarch butterfly; Box 2—Monarch Partnership), and communities, such as bats (NABat), and addresses major bottlenecks in basic science through resources such as the USGS Bee Lab at the Eastern Ecological Science Center (Box 3—USGS Bee Lab). The USGS excels in the coproduction of science by actively engaging with a broad spectrum of partners, including Federal, State, Tribal, NGO, and industry partners. This coproduction approach extends beyond collaboration to a comprehensive management lifecycle approach within which researchers, managers, and related stakeholders work as partners on the science, from developing research questions to analyzing results, ensuring the science products meet the needs of the end-user.

Working with multiple partners gives the USGS' distributed network of scientists and a broad array of stakeholders the perspective to identify and address shared needs across collaborators. Coproduced knowledge and

Box 2. Monarch Conservation Science Partnership

The USGS is a founding member of the Monarch Conservation Science Partnership (hereafter referred to as the "Monarch Partnership"), a consortium of biologists, policy analysts, natural resource managers, and decision makers from National, regional, and State natural resource management bureaus, coproducing science to address long-term declines in monarch butterfly abundance. This multibureau partnership is organized around the following five topics:

1. A threats assessment (Thogmartin and others, 2017a).
2. An estimate of species status, trend, and risk of extinction (Semmens and others, 2016).
3. A full-annual-cycle demographic model for understanding the relative contribution of portions of the annual cycle to the monarch population (Oberhauser and others, 2017).
4. A policy assessment identifying conservation efforts necessary to recover the species (Thogmartin and others, 2017b).
5. The development of the "Monarch Conservation Planning Tool," a decision support tool to aid managers and biologists in making sound conservation delivery decisions.

The Monarch Partnership's investigations helped inform the FWS's ESA listing determination (U.S. Fish and Wildlife Service, 2024a). The Monarch Partnership then moved to potential recovery planning, principally by designing the Monarch Joint Venture's Integrated Monarch Monitoring Program (for example, Cariveau and others, 2019; Weiser and others, 2020) and assisting NGO and extra-governmental organizations in delivering on the scientific insights of the Monarch Partnership. This aid was instrumental, for instance, to the Midwest Association of Fish and Wildlife Agencies' "Mid-America Monarch Conservation Strategy" and the FWS's "Nationwide Candidate Conservation Agreement with Assurances (CCAA) for Monarch Butterflies," the largest CCAA ever initiated. This CCAA is an arrangement for conservation of at-risk species, such as the monarch butterfly, helping land managers create management strategies that benefit the species, are cost-effective, and provide certainty for the management entity as to the appropriateness of their activities, if the species is listed. This domestic science partnership served as motivation for the formation of the Trinational Monarch Science Partnership, a collaboration of government scientists from Canada, the United States, and Mexico, working on monarch conservation across North America.

Box 3.
USGS Bee Lab at the Eastern Ecological Science Center

The USGS provides science support related to inventory and monitoring method development and services related to native bee identification. The USGS Bee Lab (https://www.usgs.gov/labs/usgs-bee-lab-at-the-eastern-ecological-science-center/about) is hosted by the USGS Eastern Ecological Science Center, in Laurel, Maryland, and brings together scientists from several Federal agencies. The Bee Lab is a valuable national resource for developing techniques for improving the inventorying and monitoring of native bees and providing training and services for the identification of native bees. The Bee Lab offers a series of courses on the identification of bees throughout the year, and educational opportunities are provided for citizen scientists. Together, these efforts help to compile information on bee natural history and taxonomy and to provide visual material that helps increase interest in bees in the United States and internationally.

Goals of this lab include developing and evaluating survey techniques for bees. Bee surveying is a challenge given their small size and difficult identification. Therefore, the lab provides identification services and classes in bee taxonomy that help others acquire identification skills to help in status assessments. As of 2024, the Bee Lab has processed and identified more than 700,000 individual bees. The lab provides a unique, widely used high-resolution catalog of more than 4,500 photographs of bees, other insects, and plants that is useful for management, research, and education. Additionally, Bee Lab scientists have collaborated with many taxonomic experts to develop identification tools, which are hosted by Discover Life (https://www.discoverlife.org).

Photograph showing a resin collecting bee. The bee was collected in Talbot County, Maryland. Photograph by Wayne Boo, U.S. Geological Survey Native Bee Inventory and Monitoring Lab.

tools are used and implemented by managers and decision makers, and are more likely to be seen as credible, relevant, and timely by other stakeholders than knowledge and tools that are not coproduced (Beier and others, 2016). Working hand-in-hand with partners, the USGS develops and helps implement systems and techniques that efficiently provide data needed to understand status and trends, ecological needs, and stressors (Box 4—Western Bumble Bee). The application of USGS pollinator science ranges from local to national and international scales, supporting local managers with the design of site-specific pollinator habitat, as well as national managers and international communities to prioritize restoration and conservation locations.

Box 4.
Science Supporting Listing Consideration for the Western Bumble Bee

The USGS provides science on species of conservation concern. Working closely with the FWS, 2 years prior to the initial timeline for the Species Status Assessment (SSA) of the *Bombus occidentalis* (Green, 1858; Western bumble bee), USGS researchers convened a group of experts across the species' range, reviewed existing literature, and evaluated data to identify gaps in the knowledge for bumble bee communities and the Western Bumble Bee (Graves and others, 2020). This helped spur new data collection and analysis of questions important to the FWS's framing of the SSA, such as whether the two subspecies (*Bombus occidentalis occidentalis*, Green, 1858 and *Bombus occidentalis mckayi*, Ashmead, 1902) had enough differences to be separate species. The USGS worked with the FWS and their expert team to analyze estimated distributions and trends used to develop the SSA (Janousek and others, 2023). In assessing occupancy for current conditions and future scenarios, the USGS incorporated hypothesized mechanisms of changes in bee occupancy, including drought, land cover change, and pesticides. Future scenarios included consideration of directly and indirectly modeled sources of population change. The analyses used ecoregions defined by the FWS that allowed them to assess the species' resiliency, redundancy, and representation for use in the listing decision. These products were also useful to the SSA for the *Bombus suckleyi* (Suckley cuckoo bumble bee; Green, 1860; U.S. Fish and Wildlife Service, 2024b).

Future Research Objectives, Actions, and Benefits

The declines of pollinators and widespread concern over the loss of pollination services highlight the need for pollinator research. As pollinator conservation programs and initiatives have emerged, managers, from government agencies or the private sector, and private citizens who plant backyard pollinator gardens, recognize that decisions based on sound science improve the likelihood of success. From 2015 to 2025, USGS scientists have made considerable progress toward filling some of the most pressing knowledge gaps and coordinating research efforts across the United States and, more broadly, to North and Central America. For instance, the USGS led in creating "The Butterflies and Moths of North America" (www.butterfliesandmoths.org) program, an effort to provide open access to data about butterflies and moths from Canada to Panama. The USGS was also key to the creation of the Monarch Partnership, which developed extinction risk models and recovery targets of monarch butterflies throughout eastern North America (Box 2—Monarch Partnership). USGS research is being used to inform SSAs (Box 4—Western Bumble Bee) and support range-wide monitoring efforts of endangered bees (Otto and others, 2023).

In the coming 10 years (2025–35), a broad array of knowledge gaps must be addressed to allow pollinator programs and initiatives to be successful at delivering on-the-ground conservation. The overarching objective of the USGS pollinator research community is to provide scientific leadership that supplies a broad range of stakeholders and their associated pollinator programs with information that helps them succeed in delivering conservation. The knowledge gaps that prevent confident conservation actions for pollinators are highly varied because of wide information disparities on pollinator species that decision-makers require.

During the next 10 years, the USGS will develop a framework that identifies opportunities to leverage local studies of pollinator natural history, demography, habitat use, and response to stressors to address shared, broad-scale partner needs such as understanding species distribution patterns and the effects of stressors on those patterns. Through this framework, USGS researchers can work with partners to quantify how management actions (for example, habitat enhancement, assisted migration, or captive breeding) improve conservation outcomes and develop maps and interactive tools for managers to prioritize activities considering tradeoffs among likely outcomes, uncertainties, and costs (for example, Kearns & West, 2025). Evaluating the effect of these management actions will involve biological monitoring, and the USGS will provide expertise in the design and implementation of pollinator monitoring efforts. Lastly, our USGS research framework includes the development of new technologies to improve the Nation's capacity for assessing the status and trends of native pollinators and the habitats on which they depend.

The specific science objectives and actions that the USGS will work towards over the next 10 years are detailed below. These objectives represent our future vision for USGS pollinator research and directly contribute to the information needs of the Government and the public. Each science priority is situated within the five USGS Science Themes (refer to "U.S. Geological Survey Pollinator Science Themes" section). Completing these priorities will require collaboration with other science agencies and university researchers, thereby increasing the core capabilities of each research institution.

Ecology and Natural History

Objective 1—Improved data gathering and sharing of floral resource value, nesting habitats, life cycles, life history traits, and distributions of native pollinators.

Action and benefits:

- Research life histories of pollinators to support partner and stakeholder needs. Life history research is the foundation of ecology and is needed to support virtually all aspects of species and land management.
- Create and support online databases providing tools for the support of native pollinators. Work with partners to improve access and visualization of data and results, along with interactive maps and design systems useful for supporting conservation actions, policy decisions, education, outreach, and research.

Objective 2—Assess the ecosystem and socioeconomic roles of pollinators.

Action and benefits:

- Quantify the links between native pollinators and the benefits to plants, including crops, wildlife, and humans (ecosystem services) they provide. This information would improve understanding of the ecological and socioeconomic costs and benefits of pollinators and would complement USDA's current work on managed bees.
- Assess social aspects of pollinator conservation. This research would support managers seeking to understand barriers to conservation action and create engagement strategies for use with the public.

Inventory and Trends

Objective 1—Improve national capacity for identifying native bees, butterflies, and moths.

Action and benefits:

- Provide native pollinator identification, specimen preservation, and data management training to DOI partners and other agencies. This training would help alleviate the taxonomic bottleneck that has prevented robust status and trend estimation for most native pollinators in the United States, a key problem highlighted in the Pollinator Research Action Plan (Pollinator Health Task Force, 2015). USGS leadership here has been identified as a key element for successful pollinator conservation (Kearns & West, 2025).

Objective 2—Support the development of native pollinator and habitat monitoring efforts in ways that generate compatible datasets that are available to stakeholders.

Action and benefits:

- Provide technical assistance to support monitoring efforts and develop native pollinator data curation standards in collaboration with partners and stakeholders (Kearns & West, 2025). This need is outlined in the "Pollinator Research Action Plan" (Pollinator Health Task Force, 2015) and would benefit a host of agencies that need information on the status and trends of multiple pollinator groups (Woodard and others, 2020). Traditional approaches to monitoring native bees can be costly, time-consuming, and not realistically implemented on a recurring basis across large landscapes. The USGS can provide leadership in the design of large-scale assessments that are keyed to budget and personnel limitations yet provide maximal insight into native bee conservation goals. This includes co-designing, implementing, and assessing native pollinator and habitat monitoring efforts. Monitoring helps to maintain current population levels, limiting the likelihood that species will warrant listing under the ESA, and aids the recovery efforts of listed species. The public availability of USGS monitoring data would benefit a broad group of stakeholders.

Threats and Stressors

Objective 1—Provide spatially explicit information on agrichemical application and the effects of those pesticides on pollinators and their required habitat to ensure pollination services.

Actions and benefits:

- Execute landscape assessments to understand the threats of agricultural pesticide use on pollinating insects and update the USGS Pesticide National Synthesis Project to improve chemical reporting across the United States.
- Provide species-specific field-based information on lethal and sublethal doses to native pollinator species. This information would support, for example, FWS ESA consultations with Environmental Protection Agency for listed species and Federal lands management decisions for restoration activities.

Objective 2—Document the distribution, spread, and influence of invasive species and disease on native pollinators and their habitats.

Actions and benefits:

- Identify non-native plants that improve or degrade habitat quality for pollinators, or affect pollinator health directly. This would help managers identify when non-native removal does not require immediate replacement of floral resources.

Photograph showing a three spotted digger bee (*Habropoda excellens*), collected in Utah, United States. Photograph by the USGS Bee Lab, U.S. Geological Survey.

- Improve tracking and data sharing of invasive species and disease distributions. This would allow for threat assessments of invasive species and diseases on native pollinators and their habitats.

- Support partner needs for technical assistance with rapid response plans and emerging diseases.

Objective 3—Develop climate adaptation strategies for pollinators and pollination systems.

Actions and benefits:

- Assess how drought, heat waves, floods, false springs, and loss of winter influence native pollinator species and communities, including the agricultural crops, wild plants, and wildlife they support, now and into the future under various future scenarios. This would support the Resist-Accept-Direct (RAD) framework (Schuurman and others, 2020) and other decision frameworks.

- Identify pollinators vulnerable to extreme weather conditions, such as drought and heat waves, and instances of spring emergence mismatches. This research would help identify potential management actions that may reduce negative effects on pollinators.

- Evaluate the potential for range shifts or local extirpations for at-risk species. This work would help to identify areas that may serve as refugia for pollinators now and into the future.

Objective 4—National and regional assessments of threats that pollinators face in ecosystems. Identify and develop protocols to address emerging threats.

Actions and benefits:

- For each ecoregion, assess the primary threats facing native pollinators, the scale of these threats, and their interactions with other threats. This work would help identify solutions for reducing or removing these threats to benefit pollinator health and help prioritize agency responses.

Conservation, Restoration, and Management

Objective 1—Advance methods for measuring, assessing, and mapping pollinator habitat.

Actions and benefits:

- Assess and map current pollinator habitat in the United States. This would provide policymakers and land managers with an understanding of the role of public and private land holding and land conservation programs in supporting pollinators.

- Generate maps to prioritize where habitat restoration can have the greatest effect for pollinators and other conservation targets. A critical component of these maps would be to identify which habitat factors limit populations. These maps would assist multiple land management agencies and a broad array of stakeholder groups with identifying areas where their conservation funds and efforts can be most effective and evaluating tradeoffs in costly shifts to human activities.

Objective 2—Initiate research to improve the efficacy of pollinator habitat enhancement and restoration in priority ecosystems.

Actions and benefits:

- Evaluate seed mix designs, the role of seed origin and cultivars, and planting methods to maximize pollinator value and improve the cost-effectiveness of new pollinator habitat. By evaluating the trade-offs in seed mix design and planting methods, restoration actions will have a greater impact on native pollinator communities at a reduced financial cost. Identifying the relative value of a plant

Photograph showing an orange-tipped wood-digger bee (*Anthophora terminalis*) at rest on a Canada goldenrod (*Solidago canadensis*) leaf. Photograph by Alma Schrage, U.S. Geological Survey.

species directly supports the National Seed Strategy (National Seed Strategy Keystone Initiative) by helping managers prioritize which seeds they need. This will benefit multiple Federal agencies responsible for restoring habitat on public and private lands and help the public seeking to create pollinator habitat choose the most effective plants.

- Quantify the effectiveness and impacts of management actions including prescribed fire, herbicide applications, drought intervention approaches, vegetation management, and grazing on flowering plant diversity, weed suppression, other pollinator habitat needs, and pollinator communities. This, especially when framed in the context of shifting drought, fire, and land use, would serve multiple management agencies and others responsible for supporting new and existing habitat for pollinators (for example, Kearns & West, 2025).

- Identify and evaluate opportunities to improve habitat and habitat connectivity. Mapping pollinator hotspots could identify places where new or improved habitat would provide a large return on investment. Assessing options for pairing land uses such as energy infrastructure, fuel mitigation efforts in wildland urban interfaces, agriculture, and urban areas could provide options to mitigate habitat loss and support private-public partnerships.

Methods Development

Objective 1—Develop and implement novel sampling techniques for identifying native pollinators, their host plants, habitat features, and stressors.

Action and benefits:

- Develop nonlethal technologies such as eDNA, camera trapping, and artificial intelligence for detecting pollinators and identifying their plant forage sources. These technologies will be particularly useful to address needs for monitoring vulnerable species and for estimating population trends of species where lethal take and (or) capture is not possible, does not align with stakeholder values, or could be detrimental to species of concern.

- Test and develop genetic methods for identifying native pollinators, resource needs, and potential stressors. For example, genetic barcoding can help alleviate bottlenecks associated with manual taxonomy, allow efficient characterization of bulked samples, and can be implemented as a cost-effective and rapid response for detecting emerging threats (for example, for invasive insect or pathogen detection). Barcoding pollen, microbiomes, and pathogens provides insights into diet and nutrition needs and health, which is otherwise difficult to evaluate and feed into rapid response plans.

- Develop and improve approaches for mapping resources at scales relevant to pollinators, leveraging expertise in remote sensing, machine and deep learning, hydrology, vegetation, invasive species, and geology. This will assist with evaluation of biological needs and threats, especially through envisioned interactive tools and visualizations.

Objective 2—Enhance methods for understanding population genetics

Actions and benefits:

- Provide partner agencies with detailed genetic summaries (for example, population genetics, connectivity, pathogens) of species of concern, and synthesize ecological implications of comparative analyses (for example, within priority landscapes or sharing key life-history features). Use museum voucher specimens to estimate historic population parameters and diets of pollinators that are currently at-risk but were historically healthy. Rapidly improving genetic analytical techniques provide new avenues for understanding the history of populations and can uncover threats to population viability such as loss of genetic diversity. The USGS has significant capacity in the field of conservation genetics that complements analytical capacity in other Federal agencies, such as ARS. Fostering regular communication and collaboration among geneticists within USGS and across relevant agencies will be a strategic priority for USGS.

Summary

This “Pollinator Science Strategy” outlines U.S. Geological Survey (USGS) research priorities for pollinator conservation and sustainability for the decade 2025–35. The strategy emphasizes conducting scientific research to inform management, conservation, and policy decisions, in support of animal pollinators and the services they provide to natural ecosystems and U.S. agriculture. This “Pollinator Science Strategy” was shaped through collaborative input from the USGS’s Federal, State, Tribal, nongovernmental organizations, and industry partners and identifies their key information needs regarding pollinators and pollinator habitat. It outlines several research priorities within five thematic areas and highlights the need for a research framework to connect local studies to broader national goals, evaluating the effectiveness of management strategies, creating decision-support tools, and advancing innovation in monitoring technologies. Through this research, the USGS supports the conservation, restoration, and protection of our Nation’s natural heritage, United States’ food security, and our Nation’s agricultural economy.

Photograph showing U.S. Geological Survey biologists and volunteers collecting samples of blooming flowers for a research study investigating the use of environmental deoxyribonucleic acid (eDNA) technology to detect bees that are difficult to find. Photograph by Clint Otto, U.S. Geological Survey.

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Photograph showing monarch butterflies (*Danaus plexippus*) clustering in winter in Mexico. Photograph by Emily Weiser, U.S. Geological Survey.

For more information about this publication, contact:
Director, USGS Northern Prairie Wildlife Research Center
8711 37th Street Southeast
Jamestown, ND 58401
701–253–5500

For additional information, visit: https://www.usgs.gov/centers/npwrc

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