Free Executive Summary

Status of Pollinators in North America

Committee on the Status of Pollinators in North America, National Research Council

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Summary

This report of the National Research Council's Committee on the Status of Pollinators in North America is an assessment of pollinating animals in the United States, Canada, and Mexico. To prepare this report, the committee compiled and analyzed the published literature; consulted numerous experts from academia, industry, and nongovernmental organizations; and drew from its members' extensive expertise. The extent to which the committee could discuss different pollinator species in different regions depended largely on the availability of data; the amount and quality of evidence vary widely for different animal groups. For most North American pollinator species, long-term population data are lacking and knowledge of their basic ecology is incomplete. These information deficiencies make definitive assessments of North American pollinator status exceedingly difficult. This stands in contrast to the study of pollinators in Europe, where status has been the subject of systematic investigation for some time, and where declines and extinctions have been definitively documented. Notwithstanding these gaps, the committee found sufficient evidence to determine the status of a range of both managed and unmanaged pollinators in North America.

IMPORTANCE OF POLLINATORS

About three-quarters of the more than 240,000 species of the world's flowering plants rely on pollinators—insects, birds, bats, and other animals—to various degrees to carry pollen from the male to the female parts of flowers for reproduction. Pollinators are vital to agriculture because most fruit, vegetable, seed crops and other crops that provide fiber, drugs and fuel are pollinated by animals. Bee-pollinated forage and hay crops, such as alfalfa and clover, also are used to feed the animals that supply meat and dairy products. Animal-pollinated crops generally provide relatively high income to growers than do crops pollinated in other ways.

Over and above its direct economic value to humans, pollination by animals provides essential maintenance of the structure and function of a wide range of natural communities in North America, and it enhances aesthetic, recreational, and cultural aspects of human activity. In view of that economic and ecological importance, this

report assesses the status of pollinators in North America, identifies species for which there is evidence of decline, analyzes the putative causes of those declines, and discusses their potential consequences. The committee's statement of task is provided in Box S-1.

Box S-1
Statement of Task: Committee on Status of Pollinators in North America

The National Research Council's Committee on the Status of Pollinators in North America was charged to address the following questions.

- To what degree, if any, are pollinators experiencing serious decline?
- Where decline can be established by available data, what are its causes?
- What are the potential consequences of decline in agricultural and natural ecosystems?
- What research and monitoring are needed to improve information?
- What conservation or restoration steps can be taken to prevent, slow, or reverse decline?

The first section of this summary addresses the status, causes of decline, consequences of decline, monitoring needs of managed pollinators, potential steps for their conservation and restoration, and the committee's recommendations (some in abbreviated form). The second section covers the same topics for wild pollinators. Detailed recommendations are provided in chapter 7.

MANAGED POLLINATORS

Status

Findings: Long-term population trends for the honey bee, the most important managed pollinator, are demonstrably downward. Similar data are not available for other managed pollinators, such as alfalfa leafcutter bees and bumble bees.

Among the various pollinator groups, evidence for decline in North America is most compelling for the honey bee, *Apis mellifera.* Honey bees enable the production of no fewer than 90 commercially grown crops, and beekeeping is a large commercial industry that leases honey bee colonies for pollination services across the continent.

Since 1947, the U.S. Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) has tracked honey bee colonies managed by beekeepers in the United States. Statistics demonstrate declines in 1947-1972 and 1989-1996, and a recent drop in 2005. Reports from industry journals suggest higher rates of winter kill in honey bee colonies since the advent of the parasitic mite *Varroa destructor* in the 1980's, causing temporary shortages of healthy honey bee colonies (for early season almond pollination) that are not captured by the NASS data. However, putting those declines into context is complicated by the peculiarities of NASS data collection. Because its annual survey focuses on honey production and pollinating colonies are not monitored unless they also produce honey, there are limits on the extent to which those data can be extrapolated to inform population estimates. NASS methods result in undercounting because the annual survey group consists of beekeepers with five or more hives; there is

no mechanism to count hobbyist beekeepers, who might nevertheless contribute to the supply of honey-producing or pollinating colonies. Moreover, because surveys do not consider that some honey-producing colonies travel—they are leased in different regions of the country for different seasons. These colonies can be counted more than once.

NASS also conducts a 5-year census of agriculture survey which counts all honey bee colonies just once, but definitional differences make the data incompatible with data from the annual honey survey. Yet another complicating factor is that no surveys account for colony health or for intra-year volatility in colony numbers (colonies that die early in the year, when they are critically needed for pollination, can be replaced by purchasing packages of bees or splitting surviving colonies later in the year). Finally, there is an additional complication for assessing the supply of honey bee pollinators in North America. U.S. data collection does not match what is done in Canada or Mexico. Canadian data are collected on all honey bee colonies, whether they are kept for pollination, for honey production, or both. Mexico has only recently begun a survey program—data collection began in 1990—and its collection methods were not available to the committee.

Recommendation: Improved information gathering for the beekeeping industry is critical, and the National Agricultural Statistics Service (NASS) should modify its data collection methodologies. The committee specifically recommends that NASS:

- **Refine its assessment of honey bee abundance, specifically by collecting data annually, eliminating double-counting, recording pollination services, and monitoring winter losses.**
- **Collect commercial honey bee pollination data, including crops pollinated and leasing fees, from beekeepers and from crop growers.**
- **Coordinate and reconcile data collection on honey bee colonies throughout North America. NASS should make its annual survey definitions compatible with its 5-year census of agriculture. The United States should work with Canada and Mexico through the North American Free Trade Agreement's Commission for Environmental Cooperation and the Trilateral Committee for Wildlife and Ecosystem Conservation and Management to adopt common methodologies.**

Causes of decline

Findings: Introduced parasites and pathogens clearly have harmed some managed pollinators, most notably honey bees.

Introduced parasites, particularly *Varroa destructor*, the varroa mite, clearly have contributed to reductions in managed and unmanaged honey bees. In early 2005, for the first time since 1922, pollinating honey bees were imported from outside North America, a change made possibly by a regulatory alteration to the terms of the Honeybee Act of 1922. The imports were permitted in part because of a shortage of honey bee colonies for almond pollination in California. Bee importation, however, can carry the risk of pest and parasite introduction. There is evidence that other factors also contribute to current

and potential future declines, among them antibiotic-resistant pathogens (American foulbrood); pesticide-resistant mites; and the encroachment of Africanized honey bees, particularly in the southeastern United States, a major regional source of honey bees sold or leased for the rest of the country.

Recommendation: The Animal and Plant Health Inspection Service (APHIS) should ensure that its regulations prohibit introduction of new pests and parasites along with imported bees, and Congress should extend the Honeybee Act of 1922 in principle to other managed pollinator species.

Recommendation: Through research at ARS and competitive grant programs, USDA should not only continue but also expand its efforts to:

- **Encourage innovative approaches to protecting honey bee health by**
  - **developing sustainable pest and resistance management programs for varroa mites, including identifying additional least-toxic alternative pesticides and non-chemical cultural bee management practices.**
- **Improve genetic stocks of honey bees by**
  - **refining methods for breeding, selecting, maintaining, and improving stocks with disease and pest resistance, moderated temperament, and improved honey production;**
  - **refining methods for producing high-quality queen production from selected stocks including controlling mating to ensure expression of desired traits in colonies;**
  - **expanding current efforts in germplasm preservation, including cryopreservation;**
  - **developing methods for the maintenance of European stocks in areas of Africanization;**
  - **developing a third-party certification program to ensure the quality and effectiveness of commercial queens; and**
  - **identifying genetic and genomic markers as a support to breeding programs (Chapter 6).**

Although honey bees are the most important managed pollinators, other managed non-*Apis* species also require attention. The development of management protocols for wild species and the management of agricultural landscapes to sustain wild pollinator populations can create alternatives to honey bees as pollinator demands rise and shortages become likely.

Recommendation: The USDA Agricultural Research Service should:

- **Create research entomology positions in its fruit and vegetable laboratories in geographically diverse regions of the United States to develop new non-*Apis* pollinators and establish protocols for management. These activities should augment work in the Bee Biology and Systematics Laboratory in Logan, Utah, which currently serves as a focal point for non-*Apis* research.**

- **Develop and implement bombiculture[1] disease management programs to prevent pathogen spillover to wild populations.**
- **Address pathogen problems in culturing alfalfa leafcutter bees (megachileculture) to improve pollinator efficacy and sustainability.**
- **Conduct research on landscape and farm management as related to pollinators, and provide guidance on pollinator-friendly management practices.**

Recommendation: Private-sector funding mechanisms for honey bee health and technology transfer from government research facilities should be created and enhanced to meet pollination needs. Industry checkoff programs, for example, could add honey bee pollination services to the existing crop commodity and honey programs. This private-sector effort could complement federally funded basic research efforts and promote translational research[2].

Consequences of decline

Findings: Managed pollinator decline and rising cost of pest control could increase pollinator rental fees.

Among the most conspicuous, demonstrable consequences of changing pollinator status is the rising cost of pest control in bee husbandry that has attended mite infestations of managed populations. Honey bee rental fees rise because of increasing demand attributable to growth in almond production and because of seasonal instability in honey bee populations. Notwithstanding, alternative managed pollinator species are not being widely utilized. And despite evidence of their efficacy as crop pollinators, wild species are not being effectively utilized.

Monitoring

Findings: As noted, improved information gathering for the beekeeping industry is critical, and the National Agricultural Statistics Service (NASS) should modify its data collection methodologies. In addition, the potential for the development of new management protocols to increase the use of wild pollinator species for agriculture should be explored to create alternatives to honey bees as commercial pollinator demands rise and shortages become likely.

Recommendation: USDA should establish discovery surveys for crop pollinators throughout the range of crops in North America to identify the contributions of wild species to agricultural pollination.

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[1] Domestication of bumble bees for commercial propagation.
[2] Translational research is the process of applying ideas, insights, and discoveries generated through basic scientific inquiry to industrial agricultural or medical uses.

Conservation and restoration

Findings: Research in genetics and genomics has facilitated the development and maintenance of mite- and pathogen-resistant stocks of honey bees. However, these technologies have not been widely adopted, and there is a pressing need for translational research to synthesize commercially viable practices from the results of basic research.

As noted, USDA's intramural research and competitive grant programs should expand efforts to use state-of-the-art scientific knowledge to encourage innovative and commercially viable approaches to protecting honey bee health.

WILD POLLINATORS

Status

Findings: There is evidence of decline in the abundance of some pollinators, but the strength of this evidence varies among taxa. Long-term population trends for several wild bee species (notably bumble bees), and some butterflies, bats and hummingbirds are demonstrably downward. For most pollinator species, however, the paucity of long-term population data and the incomplete knowledge of even basic taxonomy and ecology make definitive assessment of status exceedingly difficult.

Most other insect pollinators in natural and agricultural systems are not well characterized, taxonomically or ecologically, in part because of the lack of monitoring programs and in part because of a shortage of taxonomists. Overall, the paucity of long-term data prevents the documentation of population trends for almost all pollinator species. Although suggestive evidence of decline, extirpation, or extinction exists for some species, documentation of population changes is available for very few.

Notwithstanding the deficiencies in the data, there is clear evidence for decline in the numbers of some vertebrate and invertebrate pollinators. In parts of their ranges, the declines of several vertebrate pollinator species, particularly bats, are evidenced by conservation program monitoring. Long-term studies by individual investigators and regional Heritage Programs also provide evidence for declines—local and global—among wild bumble bee species and in some butterflies. Some pollinator species have been added to endangered species lists.

Recommendation: To address the taxonomic impediment to assessing pollinator status, the U.S. Department of Agriculture's (USDA) Agricultural Research Service (ARS) should expand basic research on the systematics of pollinators and on the development of rapid identification tools.

Causes of decline

Findings: The causes of decline among wild pollinators vary by species but are generally difficult to assign definitively. Pathogens that have spilled over from commercially-produced bumble bees for greenhouse pollination appear to have contributed to declines in some native bumble bees. Other factors for which there is convincing evidence include habitat degradation and loss, particularly for some bats, bees, and butterflies.

Definitive causes of decline or factors that contribute to decline in species with demonstrable changes in population status could be assigned in only a few cases. A major cause of decline in native bumble bees appears to be recently introduced non-native protozoan parasites, including *Nosema bombi* and *Crithidia bombi,* probably from commercial bumble bees imported from Europe for greenhouse pollination. The bees frequently harbor pathogens and their escape from greenhouses can lead to infections in native species. Disease, notably chalkbrood (caused by the fungal pathogen, *Ascosphaera aggregata*), also has harmed populations of *Megachile rotundata*, the alfalfa leafcutter bee, in the United States. In some species, competition with exotic pollinators (including *A. mellifera*) has led to population declines.

Declines in many pollinator groups are associated with habitat loss, fragmentation, and deterioration, although in the United States data are, in most cases, inadequate to demonstrate causation unambiguously. One exception is the decline in bat populations that is attributed to the destruction of cave roosts.

There is evidence that other factors contribute to the documented declines among other pollinators. Changes in phenological synchrony and in distributions of pollinators and plants result from global climate change could lead to a decline in interactions between flowers and pollinators. Disruption of migratory routes is evident in hummingbirds, nectar-feeding bats, and some butterflies.

Recommendation: To prevent pathogen spillover to wild populations, APHIS should require that any commercially produced bumble bee colony shipped within the United States be certified as disease-free.

Consequences of decline

Findings: The consequences of pollinator decline in nonagricultural systems are more difficult to define, but one important result could be an increased vulnerability of some plant species to extinction.

Few plant species rely on a single pollinator. Pollen limitation of seed set is common in wild plants, but its population consequences are not clear. In the event of declining pollinator populations, some plant populations that are dependent on affected pollinators for reproduction could become more vulnerable to an extinction vortex—the interacting demographic and genetic factors that progressively reduce small populations. Therefore, the effects of pollinator decline on rare plant species or on those with small populations also should be given special attention.

Recommendation: The U.S. Geological Survey, the Fish and Wildlife Service, and other agencies responsible for natural resource protection should establish discovery surveys for pollinators of rare, threatened, and endangered plant species.

Monitoring

Findings: Long-term, systematic monitoring is necessary for unambiguous documentation of trends in species abundance and richness. Such monitoring allows detection of relationships between changes in pollinator communities and the putative causes of change. Those relationships must be understood to assist in developing plans to mitigate harm or to manage species sustainably.

Pollinator-monitoring programs in Europe (for example, the Survey of Wild Bees in Belgium and France and the European Union's project, Assessing Large-Scale Risks for Biodiversity with Tested Methods) have effectively documented declines in pollinator abundance, but there is no comparable U.S. program. The lack of historical baselines to compare with contemporary survey data makes it difficult to assess pollinator status or to determine the causes of documented declines.

Recommendation: The federal government should establish a network of long-term pollinator-monitoring projects that use standardized protocols and joint data-gathering interpretation in collaboration with Canada and Mexico. A rapid, one-time assessment of the current status of wild pollinators in North America to establish a baseline for long-term monitoring is a laudable initial goal.

Components of this two-part assessment and monitoring program should include re-surveys of areas well sampled in the past and mining of museum collections and the literature for historical data that correspond to areas of continuous, high-intensity sampling as well as monitoring of pollinator status and function that integrates the work of professional scientists and citizen-scientists to maximize the depth and breadth of effort.

The selection of study species should correspond to the strength of evidence for decline. In view of collective evidence of population declines and possible extinctions, bees provide a logical initial focus. Lepidoptera constitute another group for which a compelling need for monitoring exists, given recent extinctions and the classifications of some species as endangered or threatened.

Conservation and restoration

Findings: Effective conservation or restoration of pollinator populations requires comprehensive knowledge of their biology, which is currently insufficient to inform the design of sustainable management and maintenance programs. However, many simple and relatively inexpensive practices for pollinator conservation are available. Land

managers and landowners, including farmers and homeowners, should be encouraged to adopt "pollinator-friendly" practices, many of which incur little expense. However, widespread adoption of these practices is unlikely unless there is a general appreciation of the ecological and economic benefits of pollinators. Hence, public outreach is key to pollinator protection, conservation, and restoration.

Recommendation: Because of the importance of pollination as an ecosystem service in both agricultural and natural ecosystems, the National Science Foundation and USDA should recognize pollination as a cross-cutting theme in their competitive grant programs. Representative areas where research is needed include identification of causes and consequences of pollinator decline, ecology, restoration, conservation, and management of pollinators and pollination services, and establishment of Small Business Innovation Research (SBIR) programs to promote technology transfer to address the health and sustainability of commercially-managed pollinators.

Notwithstanding deficiencies in understanding of wild-pollinator biology, viable, pollinator-friendly land management practices (such as planting native plants to enhance pollinator habitat) are known and available, although not yet been widely adopted. Farmers and ranchers can be offered economic incentives to adopt such practices.

Recommendation: Economic incentives should be expanded for pollinator conservation.

- **State-level Natural Resources Conservation Service (NRCS) offices should provide lists of scientifically tested and approved pollinator-friendly practices to farmers participating in USDA cost share programs (the Wildlife Habitat Incentives Program and the Environmental Quality Incentives Program), land retirement programs (the Conservation Reserve Program [CRP] and the Conservation Reserve Enhancement Program), and production stewardship program (the Conservation Security Program [CSP]).**
- **CRP should explicitly incorporate pollinator habitat in the environmental-benefits index used to evaluate land parcel proposals and incorporate the value of pollinator habitat development into its determination of the stewardship tiers for federal payments.**
- **USDA cost-sharing, land retirement, and production stewardship programs should be available to producers of all commodities—fruits, nuts, and vegetables—that depend on pollinators.**
- **The NRCS should target new hiring of personnel whose expertise is in biological sciences, especially ecology and natural-area management.**

Landowners other than farmers and ranchers—such as homeowners and businesses—also could contribute to the conservation of pollinators by planting wildflowers to provide floral resources for resident and migratory adult pollinators and by providing nesting sites for females. People who do not own or manage land also can help by participating in monitoring programs. Critical to the success of citizen-scientist programs, however, is effective public outreach to raise awareness of pollinators'

ecological and economic contributions and to encourage public participation in conservation.

Recommendation: As part of their outreach, federal granting agencies should make an effort to enhance pollinator awareness in the broader community through citizen-scientist monitoring programs, teacher education, and K-12 and general public education efforts that center on pollination.

Recommendation: Professional societies (Ecological Society of America, Entomological Society of America, American Association of Professional Apiculturists, Botanical Society of America) and nongovernmental organizations (North American Pollinator Protection Campaign, Xerces Society for the Preservation of Endangered Invertebrates) should collaborate with landowners and the public to increase awareness of the importance of pollinators and to publicize simple activities the public can do to promote and sustain pollinator abundance and diversity.

Although the object of the Endangered Species Act of 1973 (ESA) is to protect endangered species and their habitats, many endangered pollinators are not recognized as candidate species for two reasons. First, Congress directed that listing of species requires a scientific determination of its continued existence as threatened or endangered, but data on many pollinators are sketchy. Second, a 1981 congressional revision of the ESA specifically exempted any "species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man." Some caterpillars and carpenter bees, for example, can cause economic damage. Thus, it might be difficult to present sufficient evidence to list them.

Recommendation: Congress should not consider any Endangered Species Act amendment that would create additional barriers to listing pollinator species as endangered.

Status of Pollinators in North America

Committee on the Status of Pollinators in North America

Board on Life Sciences
Board on Agriculture and Natural Resources
Division on Earth and Life Studies

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Preface

The magnitude and direction of all manner of anthropogenic global environmental change have lately come to dominate the national conversation: at the movies, on the internet, and in the press. Entering the term "environmental crisis" on Google generates close to 52 million hits, and the debate is raging over the validity of various projections of consequences and diverse proposals for remediation. Of the multitude of ways humans could be harming the planet, however, one that has largely been ignored is the "pollinator crisis"—the perceived global decline in the number and viability of animal species that facilitate reproduction of flowering plants, the overwhelming majority of plants in terrestrial communities. In her hugely influential book *Silent Spring* published more than 40 years ago, Rachel Carson recognized the central role of pollinators. They are the proverbial birds and the bees, along with many other insect species and even a handful of mammals, that maintain human health and terrestrial biodiversity. Carson painted a bleak picture of a world with "fruitless falls." In the intervening decades, reports have quietly accumulated from virtually every continent of shortages or extinction of pollinators of various descriptions.

Ironically, despite its apparent lack of marquee appeal, pollinator decline is one form of global change that actually does have credible potential to alter the shape and structure of the terrestrial world. Over the past decade, the public has begun to take notice and ask whether a pollinator crisis is brewing and, if so, what can be done to avert it. The National Research Council, in keeping with its charter to provide independent, objective analysis and advice on scientific matters of national importance, took on this issue at the request of the U.S. Department of Agriculture and the U.S. Geological Survey and commissioned a study; overseeing the study process were the Board on Agriculture and Natural Resources and the Board on Life Sciences.

Because the efforts of pollination are so pervasive ecologically and economically, the committee charged with assessing the status of pollinators required representation of a breadth of interests and abilities. The 15 members came from across the United States, Canada, and Mexico, and their expertise encompasses ecology, population biology, ethology, genetics, evolutionary biology, botany, entomology, systematics, agricultural economics, apiculture, and conservation biology (Appendix A). The committee devoted more than a year to examining literature, meeting with the experts who are most familiar with the lives of pollinators, and meeting with people whose livelihoods depend on pollinator activities. Evonne Tang, Senior Program Officer for the Board of Life Sciences, labored brilliantly and tirelessly to arrange

meetings, secure information, make contacts, and reconcile and edit numerous versions of the report. Fran Sharples, Director of the Board on Life Sciences, was generous with administrative, scientific, and moral support. From the Board on Agriculture and Natural Resources, Robin Schoen, director; Karen Imhof, administrative assistant; and Peggy Tsai, research associate, provided invaluable guidance, organizational effort, and logistical assistance in support of the project

It seems particularly appropriate that a study examining the health and well-being of the premier ecological mutualism on the planet should result from mutual respect and cooperation among a group of dedicated scholars. That the conclusions reached by the committee and presented in this report will inspire a rash of Hollywood disaster films is extremely unlikely—tidal waves, floods, fires, and explosions still remain inherently more cinematic than just about anything involving flowers, birds, bees, and butterflies—but it is to be hoped that the recommendations will inspire discussion and action nonetheless.

May Berenbaum
Chair, Committee on the Status of
Pollinators in North America

Acknowledgments

This report is a product of the cooperation and contributions of many people. The members of the committee thank all of the speakers who attended its first committee meeting on July 6, 2005, the workshop on October 18-19, 2005, and the third committee meeting on January 14, 2006 and others who provided information and input. (Appendix B presents a list of presentations to the committee.)

This report has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following for their review of this report:

Deane Bowers, University of Colorado, Boulder
Susan Mazer, University of California, Santa Barbara
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Don Wilson, U.S. Fish and Wildlife Service
Ada Wossink, North Carolina State University

Although the reviewers listed above provided constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Drs. Frederic L. Gould of North Carolina State University and Mary Jane Osborn of University of Connecticut Health Center. Appointed by the National Research Council, Drs. Gould and Osborn were responsible for making certain that an independent examination of this report was carried out in accordance

with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the author committee and the institution.

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