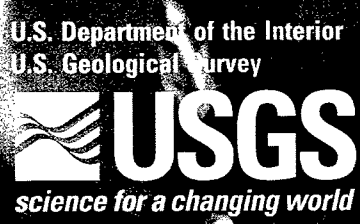


# Report of the U.S. Department of Agriculture and U.S. Department of the Interior Joint Workshop on Declining Pollinators

27-28 May 1999  
Logan, Utah

Information and Technology Report  
USGS/BRD/ITR-2000-0007

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



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*Cover photos:* Background, smooth hawk's beard (*Crepis runcinata*), Robert E. Stewart, Sr.; lesser long-nosed bat (*Leptonycteris curasoae*), Merlin D. Tuttle, Bat Conservation International; gulf fritillary (*Agraulis vanillae*), U.S. Geological Survey; ambush bug (*Phymata erosa*), Stephen R. Johnson, U.S. Geological Survey; broad-tailed hummingbird (*Selasphorus platycercus*), courtesy of U.S. Department of Agriculture and taken by Jack Dykinga; bee (*Andrena* sp.), Howard Ginsberg, U.S. Geological Survey.

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by

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# Agenda

## Thursday, May 27

- 9:00 a.m. Welcome and workshop overview - Bill Kemp, USDA
- Introductory comments - Bill Gregg, USGS, and Will Blackburn, USDA

### **Pollinator declines - Evidence and causes**

- 9:15 a.m. Introduction - Vince Tepedino, USDA, moderator
- 9:25 a.m. Evidence of pollinator declines - Steve Buchmann, USDA
- 9:50 a.m. Pesticides and pollinator decline - Peter Kevan, University of Guelph, Canada
- 10:15 a.m. Break
- 10:30 a.m. Detection of changes in populations and faunas - John Sauer, USGS
- 10:55 a.m. Current status of bee taxonomy: challenges and opportunities - Terry Griswold, USDA
- 11:20 a.m. Discussion: data gaps, research needs, and areas of collaboration (Steve Buchmann, USDA)
- 12:30 p.m. Lunch

### **Pollinator declines - Problems for agriculture**

- 1:30 p.m. Introduction - James Cane, USDA, moderator
- 1:40 p.m. Honeybee declines and effects on crop pollination - P. Kirk Visscher, University of California, Riverside
- 2:05 p.m. Bumblebees as agricultural pollinators: potentials and problems - Robbin Thorp, University of California, Davis
- 2:30 p.m. Break
- 2:45 p.m. Native solitary bees as alternative crop pollinators - Jim Cane, USDA
- 3:10 p.m. Delivery of native blue orchard bee as an orchard pollinator - Jordi Bosch, USDA
- 3:35 p.m. Discussion: data gaps, research needs, and areas of collaboration (Bill Kemp, USDA)
- 5:00 p.m. Adjourn

### **Evening activity**

- 8:00 p.m. Informal tour of USDA Bee Biology and Systematics Laboratory

**Friday, May 28**

**Changing patterns in pollination of wild plants**

- 8:30 a.m. Introduction - Howard Ginsberg, USGS, moderator
- 8:40 a.m. Native plants and native pollinators - Vince Tepedino, USDA
- 9:05 a.m. Native plants, avian and insect pollinators, and invasive species in Hawaii - Joan Canfield, USGS
- 9:30 a.m. Native invertebrate pollinators in forest ecosystems - Jim Hanula, USDA Forest Service
- 9:45 a.m. Lepidoptera as forgotten pollinators - Paul Opler, USGS, retired
- 10:10 a.m. Break
- 10:25 a.m. Status of vertebrate pollinators in North American forests - Gary Paul Nabhan, Arizona Sonora Desert Museum
- 10:40 a.m. Status of bat pollinators - Mike Bogan, USGS
- 11:05 a.m. Invasive plants and pollination of native plants - Diane Larson, USGS
- 11:30 a.m. Discussion: data gaps, research needs, and areas of collaboration (James Thomson, State University of New York, Stony Brook)
- 12:30 p.m. Lunch

**Developing a joint research strategy for USDOJ and USDA**

- 1:30 p.m. Research strategy and development of budget initiatives on pollinator declines - Mike Ruggiero, USDOJ, and Bob Vander Meer, USDA, moderators
- 3:00 p.m. Break
- 3:15 p.m. Resumed discussion
- 4:30 p.m. Summary and closing remarks - Denny Fenn, USGS, and Will Blackburn, USDA
- 5:00 p.m. Adjourn

**Evening activity**

- 8:00 p.m. Informal tour of USDA Bee Biology and Systematics Laboratory

## Executive Summary

A workshop was held on 27-28 May 1999 in Logan, Utah, to assess current knowledge on the status of pollinator populations and to recommend research directions for the U.S. Department of Agriculture (USDA) and the U.S. Department of the Interior (USDOI). The 24 participants included federal scientists and selected university and museum researchers. Presentations emphasized evidence of possible declines in pollinator populations, factors impacting pollinators, the effects of changes in pollinator service on natural and agricultural systems, and management approaches to deal with changing pollinator faunas.

The participants identified seven broad issues relevant to pollinator declines, as well as numerous research needs associated with these issues. The seven issues were (1) the relationship between pollination and ecosystem health; (2) landscape-level patterns of pollination (especially along a cline from wild lands to agricultural, suburban, and urban environments); (3) multiple factors that simultaneously influence pollinator populations (such as habitat fragmentation, pesticides, and invasive species); (4) bioprospecting (e.g., among wild pollinators for potentially valuable agricultural pollinators) and biodiversity; (5) development of restoration and management practices for pollinators; (6) public education about the importance of pollinators; and (7) implications of pollination considerations for policy options.

Research is recommended on several topics associated with these issues:

*Monitoring.* Long-term monitoring programs should be established for feral honeybees and selected native pollinator species.

*Biological survey.* Pollinators and plant-pollinator relationships should be surveyed and compared among natural, agricultural, suburban, and urban environments.

*Taxonomy/systematics.* Additional resources, including full-time equivalent employees, need to be applied to taxonomy and systematics of pollinators, especially bees.

*Roles of pollinators in natural and agricultural systems.* Research is needed to establish the values of wild pollinators to natural systems and for crop production. The potential effects of changes in pollinator populations on natural communities and on agricultural productivity need to be assessed as well.

*Restoration.* Study is needed on management methods to restore pollinator populations that have been extirpated or artificially modified.

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U.S. Department of Agriculture and  
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Joint Workshop on Declining Pollinators**

**27-28 May 1999  
Logan, Utah**

by

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**Abstract:** Pollinators such as bees, birds, and bats are important components of agricultural and natural ecosystems. Current evidence suggests that populations of some pollinators are declining because of habitat loss and fragmentation, pesticide use, and the effects of invasive species. The U.S. Department of Agriculture and the U.S. Department of the Interior held a joint workshop on declining pollinators to assess the current status of pollinator populations and to recommend research directions for their agencies. The two-day workshop on 27-28 May 1999 in Logan, Utah, included presentations by federal scientists and university and museum researchers on the evidence and causes of pollinator declines and on resulting problems for agriculture, changing patterns in pollination of wild plants, and implications for natural communities. The participants discussed research needs and joint research strategies for both agencies. Important recommendations included establishing monitoring programs to assess trends in pollinator populations, conducting biological surveys of pollinators, fostering study of bee systematics, assessing the roles of pollinators in natural and agricultural systems, and restoring pollinator habitat.

**Key words:** Pollinators, agricultural ecosystems, natural ecosystems, monitoring, pollinator populations, bee systematics

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## Introduction

On May 27th and 28th, federal scientists and administrators and selected university researchers convened in Logan, Utah, under the auspices of the USDA and USDO I to discuss the implications of pollinator decline for natural systems and agrosystems (see Agenda and List of Participants). Presentations were made on the status of feral, domesticated, and semidomesticated populations of the honeybee (*Apis mellifera*), bumblebees (*Bombus* sp.), several species of "solitary" bees, and vertebrate pollinators such as bats (Chiroptera). Special attention was given to changes in the population numbers of these important pollinators and their potential effects on agriculture and natural communities.

Pollinators play an important role in natural systems by mediating sexual reproduction in plant populations. They thereby exert direct effects on plant demography and population genetics, and on plant community composition, and they exert indirect effects on all higher trophic level organisms that use plants for food or shelter. Pollinators are also important in agriculture because of their direct influence on fruit and seed yield of many crops. The recent book, *The Forgotten Pollinators* (Buchmann and Nabhan 1996), has drawn attention to likely declines in pollinator populations and sounded a warning call about the potential implications of these declines. Soon after, the Society for Conservation Biology published a position paper (Allen-Wardell et al. 1998) examining the potential implications of pollinator declines and calling for additional research on this issue. The possible causes and implications of changes in pollinator populations have also received some attention in the scientific literature (e.g., LaSalle and Gauld 1993; Matheson et al. 1996; Butz Hury 1997; Kearns et al. 1998; Kevan 1999), but solid evidence on the occurrence and implications of pollinator declines remains thin.

## Summary of Presentations

Current evidence suggests that it is not at all clear that honeybee populations are continuing to decline because of Varroa mites (*Varroa jacobsoni*) and tracheal mites (*Acarapis woodi*) (Visscher; see Agenda). Indeed, there is a bit of preliminary evidence from a few scientists to suggest that feral populations may have begun to rebound; however, quantitative data on national trends in feral honeybee populations are generally lacking. The Africanized honeybee (AFB) may be in a secondary breakout stage after several years of population semistasis: AFB's appear to be advancing north at more rapid rates than in recent years from beachheads in southern Arizona, California, and Texas and represent a

potential problem for agricultural crops that require pollinators. For most areas of the country, the data to answer important questions about honeybee population dynamics are not available and are not being collected.

The use of bumblebees for greenhouse pollination, especially crops of the Solanaceae family such as tomatoes, peppers, and eggplants, is increasing (Thorp; see Agenda), but bumblebees (*Bombus occidentalis* in particular) are no longer being commercially produced on the west coast. Instead, the eastern species *Bombus impatiens* has been cleared for importation into many western states for agricultural use in large greenhouses. Even more recently, the aggressive Middle Eastern species, *Bombus terrestris*, has been imported into Mexico, where it could potentially escape into North America. Natural bumblebee populations are not being monitored for population trends, but it was generally agreed that their populations likely continue to fluctuate widely in response to a variety of abiotic and biotic conditions.

Solitary bees, both natives and accidental introductions, are playing a growing role in the pollination of agricultural crops (Cane, Bosch; see Agenda). In addition to time-tested alfalfa pollinators such as the alfalfa leafcutting bee (*Megachile rotundata*) and the alkali bee (*Nomia melanderi*), other natives such as the blue orchard bee (*Osmia lignaria*), a related blueberry bee (*Osmia ribifloris*), and the sunflower leafcutting bee (*Megachile pugnata*) are in the pipeline for future delivery to growers. Although research on commercial propagation of these species is in progress, currently the only major source of these species of bees is lands managed by the USDA Forest Service, by the USDO I (primarily Bureau of Land Management [BLM]) and by other federal agencies. Thus, conservation and stewardship of our native bee species on federal lands is of great importance to our effort to develop supplementary and alternative crop pollinators.

Among the threats to native bee populations, and, indirectly to the crops and native plants they pollinate, are pesticides, especially broad-spectrum insecticides and herbicides (Kevan; see Agenda). Toxicological information on the effects of most insecticides on native solitary bee species is mostly unavailable, and we must make inferences from results of studies on more readily available species such as the honeybee. This is a less than completely reliable tactic since it has been shown that species such as the alfalfa leafcutting bee and the alkali bee have insecticide sensitivities that differ somewhat from those of the honeybee. Herbicides affect bees indirectly by destroying pollen and nectar sources supplied by native and introduced flowering plants.

Another important threat to bee populations, particularly to the undomesticated native species responsible for

pollinating our native flora, as well as to those with potential as supplementary crop pollinators, is habitat loss and fragmentation (Tepedino, Nabhan; see Agenda). Habitat loss, that is, conversion of natural areas to places of human habitation, industry, or commerce, poses an immediate and frequently irreversible threat to pollinators. Studies of the effects of habitat fragmentation on other insect groups, and on vertebrates, are not necessarily applicable to bees because of their distinct biology: bees are central place foragers whose food and shelter needs may require them to travel long distances from nest to food, water, and structural resources.

Other threats discussed included a variety of introduced species, both plants and animals, which negatively interact both directly and indirectly with native pollinators and with the plants they service (Canfield, Larson; see Agenda). For example, invasive species have had profound effects on the Hawaiian fauna and flora, and extraordinary efforts are currently required to provide pollinator service to rare native plant species. Unmentioned, but nevertheless with important impacts on insect pollinators, are livestock (as grazers of food plants, trampers of bee nest sites, and actors encouraging broad-spectrum insecticide spraying for grasshoppers on federal rangelands); removal of stumps, slash, snags, and other potential wood nesting sites from intensely managed forest lands; and uncontrolled use of off-road vehicles, which cause erosion, alter plant species composition, and render areas unacceptable to ground-nesting bees through soil compaction and obliteration, especially during the nesting season.

Trends in insect pollinator populations and faunas are statistically difficult to document, but innovative approaches are being developed to assess changes in pollinator faunas through time (Sauer; see Agenda). We tentatively concluded that although evidence is slim and mostly from non-North American examples (Buchmann; see Agenda), insect pollinator declines are likely, at the very least, in areas with high levels of human activity. Populations of selected butterfly species are likely among those that have declined. The importance of butterflies as pollinators, however, in either natural systems or agroecosystems has not been demonstrated (Opler; see Agenda). Declines in vertebrate pollinator populations, particularly migratory bird species and bats, appear to be better documented (Nabhan, Bogan; see Agenda). Maintenance of migration corridors is important to maintain populations of migratory vertebrate pollinator species. Compared to insect pollinators, these vertebrate pollinators have relatively little importance for major agricultural cash crops in North America but are important in natural systems in arid southwestern North

America and in tropical areas in Mexico and Central America.

Numerous suggestions for research on pollinators and the plants they visit were offered during a scoping session that ended the workshop (Ruggiero and Vander Meer; see Agenda). We have tried to distill from those many suggestions what we feel are the most important research questions that can benefit both USDA and USDOJ. Many research topics mentioned during the session are better explored by one of the agencies alone or by collaboration with university scientists. In this report, we restrict our suggestions to the areas of monitoring, biological survey, study of the roles of pollinators in natural and agricultural systems, and restoration.

### ***Issues and Research Needs***

The workshop participants identified seven general issues associated with pollinator declines that require special attention. Research needs associated with each issue were compiled.

#### **(1) Pollination and Ecosystem Health**

Changes in pollinator populations undoubtedly influence plant populations and thus natural communities, but little information is available about long-term trends in pollinator faunas and the effects of these trends on ecosystem processes. Research needs identified with this issue area are listed in Box 1. Priorities include establishing monitoring programs to assess patterns of change in pollinator numbers and diversity, and determining which plant species are pollinator-limited (especially endangered species) so as to assess vulnerability of natural systems to pollinator decline.

#### **(2) Landscape Scale and Patterns**

Important landscape-level factors that influence pollinator populations include habitat fragmentation, loss, conversion, and land-use patterns. Research needs associated with landscape-scale effects are listed in Box 2. Research on changes in pollinator faunas, and resulting effects on the dynamics of pollination systems along a cline from wild lands to agricultural, suburban, and urban areas would be particularly valuable. In addition, the importance of preservation of "nectar corridors" for migratory pollinators (e.g., sites along migration routes of bird and bat pollinators) for maintenance of pollinator populations needs to be assessed. Preservation of crucial sites can be incorporated into conservation plans and resource management programs on federal lands.

### Box 1. Research Needs: Pollination and Ecosystem Health

- Monitor long-term changes in pollinator guilds
- Assess effects of changes in pollinator service on ecosystems
- Examine value of pollinator redundancy for stability of natural systems
- Assess whether plants are pollinator-limited; assess pollination deficits in:
  - (a) natural systems in general
  - (b) rare and endangered plant species
  - (c) agroecosystems
- Identify model ecosystems and appropriate sites for research
- Delineate ecosystem services provided by pollinators
- Identify vulnerabilities in plants or ecosystems to pollinator declines
- Examine the question of what is a "healthy" ecosystem for pollinators
- Compile additional information on floral host associations of pollinators
- Assess spatiotemporal variability in pollinator assemblages and its effect on plant reproduction

### Box 2. Research Needs: Landscape Scale and Patterns

- Study pollination dynamics (including plants) at the agriculture-wild land interface (including urban-suburban areas)
- Assess the role of nectar corridors; identify and map corridors, study the required configuration of corridors for migratory species
- Study the effects of landscape fragmentation on pollinator populations and plant pollination
- Study how pollinator movements link landscape units
- Predict effects of pollinator declines on landscape-level patterns
- Assess how differences in pollinator guilds influence productivity in different parts of a plant's range
- Assess the effects of size and distribution of plant populations on pollinator communities
- Examine the effects of invasive plant species on pollinator movement in landscapes
- Evaluate the potential contribution of invasive plant species to increases in pollinator populations

### (3) Multiple Factors

Numerous factors drive trends in pollinator populations, including invasive species, pathogens, pesticides, genetically modified organisms, habitat fragmentation and loss, distribution and phenology of flower bloom, etc. Often, multiple factors operate simultaneously to stress, or to enhance, pollinator populations. Research needs identified in this area are listed in Box 3. The effects of interaction of multiple drivers on pollinator populations, and the relationships between native pollinators and introduced plants, are of particular importance.

### (4) Bioprospecting and Biodiversity

The rich native bee fauna of North America provides an extensive resource for "bioprospecting" for potentially valuable crop pollinators. An essential first step is

to describe this fauna, so resources need to be applied to systematic study of pollinators. Development and integration of computer databases, and of associated methods to identify pollinators, would be invaluable. Study on the potential effects of bioprospecting on natural populations is also important. Research needs are listed in Box 4.

### (5) Restoration and Management Practices

Real-world application of basic knowledge about pollinators, their interactions with plants, and associated ecosystem and landscape-level effects, will require practical knowledge about techniques to restore pollinators and to preserve their habitats. Research questions about restoration and management are listed in Box 5. Improved propagation techniques for pollinators and their host plants would clearly be valuable. Homeowners, local associations, and park

**Box 3. Research Needs: Multiple Factors**

- Study effect of habitat fragmentation on pollinator dynamics and plant reproduction
- Evaluate effects of interaction of multiple stresses on pollinators
- Develop integrated pest management for pests of managed pollinators
- Examine interactions of invasive plant species, native plants, and pollinator guilds
- Study pesticide effects on native pollinators
- Evaluate the potential use of nonnative pollinators for native plants
- Develop decision support systems for screening potential invasives
- Assess the effects of genetically modified organisms on pollinators
- Assess the potential effects of climate change and extreme events on pollinator populations

**Box 4. Research Needs: Bioprospecting and Biodiversity**

- Enhance taxonomic capabilities in USDA and USDO1
- Complete the publication, "Bees of North America"
- Comprehensively compile the publication, "Pollinators of North America"
- Examine the effects of bioprospecting
- Accelerate release of candidates for crop pollination
- Enhance technology transfer to agriculture
- Assess and demonstrate value of set-aside lands for pollinators
- Determine relative pollination efficiency of various taxa for insect-pollinated crops
- Enhance bioprospecting and screening of surrogate pollinators, including foreign prospecting
- Develop a gap analysis program for pollinators
- Develop and integrate museum databases
- Evaluate use of pollinators for biomonitoring for agricultural and wild lands
- Develop new bee identification tools

**Box 5. Research Needs: Restoration and Management Practices**

- Evaluate critical habitat size for pollinators and host plants
- Develop propagation techniques for pollinators and host plants
- Study impacts of disturbance on pollinators (fire, grazing, etc.)
- Evaluate conflicts of management practices on pollinators
- Develop methods for control of invasives
- Develop bee garden methodologies and methods for habitat enhancement for pollinators (roadsides, hedgerows, golf courses, etc.)
- Develop methods to reintroduce pollinators to restored lands and mitigated habitats
- Study interactions of multimanaged pollinator species
- Develop criteria to evaluate restorations (relative to pollination)
- Monitor restoration programs
- Assess impacts of introduced pollinators on genetic diversity of native pollinators
- Assess influence of public attitudes and behaviors on restoration

and golf course managers, for instance, can potentially participate in pollinator enhancement programs (e.g., by planting flowers that provide nectar and pollen during periods of flower dearth) once optimal management methods have been developed. Research is recommended on the effects of current management practices on pollinators and on potential alternatives for practices that have adverse effects on pollination systems.

## (6) Education

The research projects outlined in the previous sections can provide information useful to scientists and resource managers for dealing with potential pollinator declines. It is essential that people outside these professional communities be aware of the importance of pollinators in natural ecosystems and in agriculture. Furthermore, participation by the general public is essential to the success of broad-scale conservation programs for pollinators. There are numerous opportunities in the recommended projects for educational programs on pollinators and for public participation in data-collecting and in pollinator conservation programs.

## (7) Policy Options

Results of the research studies outlined here have implications for decisions about policy options in both the USDA and the USDOJ. The information and understanding resulting from these studies will provide guidance in selecting alternative management practices on federal lands.

### **Research Recommendations**

*Monitoring trends in pollinator populations.* We recommend establishing a national system for the long-term monitoring of pollinators, including feral honeybees, selected native and perhaps introduced bee species, and important vertebrate pollinators. The details of this monitoring scheme remain to be worked out but should include all areas of the country as well as representative species from diverse taxa with different nesting behaviors (e.g., twig-nesters, ground-nesters, etc.) and different degrees of host-specificity. Monitoring should be coupled with research projects designed to assess the effects of multiple driving factors on populations of pollinator species.

*Biological survey.* Surveys of the occurrence and distribution of bees, especially comparisons of species in urban, suburban, rural, and "natural" surroundings, are essential to better understand the effects of anthropogenic activity on pollinating bees. Native solitary bee species are receiving increasing attention as pollinators in agroecosystems. The populations we obtain to conduct our experiments, and the species that will eventually

pollinate selected crops, can most readily be found on federal land administered by USDA (Forest Service) and USDOJ. To facilitate obtaining populations for research and eventual commerce, we need a survey of populations in their natural surroundings that will provide us with detailed information on bee species distributions together with their host plant preferences.

*Taxonomy/systematics.* Neither monitoring nor surveys are feasible without increased attention to specimen curation and identification. Taxonomy/systematics is the very base that supports all the other research recommendations we make here. We recommend that FTE's be allocated to hire Ph.D.-level systematists to extend our currently crude understanding of bee systematics and to handle the overwhelming specimen-identification load for bee taxonomists. We also suggest the training of parataxonomists to handle routine identifications of specimens for research and monitoring programs.

*Role of natural pollinators in natural and agricultural systems.* The roles of native bee pollinators in natural and agricultural ecosystems need to be clearly assessed. Such assessments will allow us to provide well worked-out examples of the value of biodiversity in general, and pollinators specifically, in ecosystem function and in agricultural productivity.

(a) *Natural systems.* In natural systems, pollinators act as keystone mutualists whose activities are necessary for the sexual reproduction of roughly two-thirds of flowering plants and, in turn, for the growth and survival of animals that harvest all, or parts, of those plants for their food and for the food of their progeny. For example, a large proportion of all North American bird species use fruits and seeds for food at some time in their yearly cycles. We should attempt actual research-based estimates of this value. Furthermore, any change in pollinator service to plants (resulting from declines in pollinator populations, introduction of nonnative pollinator species, or spread of invasive plant species) can change trends in plant reproduction, and thus have potentially broad effects on natural communities. Research is needed on these potential secondary effects of changing patterns of pollinator service in natural communities.

(b) *Agricultural systems.* We need to evaluate the value of bee species as pollinators of backyard garden crops, and of crops that are grown adjacent to or near federal wild lands or private set asides such as conservation reserve program land. Thus, we envision a series of collaborative studies that evaluate the importance of natural pollination to a variety of agricultural crops grown in environs that vary in ecological diversity.

*Restoration.* While estimating the value of bee pollinators, we must also demonstrate effective techniques for restoring pollinator habitat that has been destroyed or modified. Myriad possibilities exist for potential restoration of native plants and pollinators on small and intermediate-sized scales. Some of these are already being explored in a modest way, and these studies should be expanded. Examples include habitat restoration in urban parks and monuments, especially those administered by USDOJ, private golf courses, industrial parks, hospital grounds, apartment complexes, and college and university grounds.

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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This responsibility includes fostering the sound use of our lands and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities.



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