U.S. Air Force Pollinator Conservation Reference Guide

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U.S. Air Force

Pollinator Conservation Reference Guide

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PREFACE

The *U.S. Air Force (Air Force) Pollinator Conservation Reference Guide* (*Reference Guide*) was developed collaboratively by the U.S. Fish and Wildlife Service (USFWS) and Air Force Civil Engineer Center (AFCEC). The Air Force, through AFCEC and with the assistance of USFWS and the state fish and wildlife agencies, is responsible under the Sikes Act (16 U.S.C. 670a-670f, as amended) for carrying out programs and implementing management strategies to conserve and protect biological resources on its lands. AFCEC assists installation environmental programs to ensure military mission activities are conducted in compliance with all applicable environmental laws, regulations, and policies. The primary objective of Air Force natural resources programs is to sustain, restore and modernize natural infrastructure to ensure operational capability and no net loss in the capability of Air Force lands to support the military mission of the installation.

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HOW TO USE THIS REFERENCE GUIDE

This *Reference Guide* is intended for natural resource and pest management professionals.

Introduction: Natural resource and pest management professionals:

- Read this section to learn about pollinators and their importance.

Section 1: Natural resource management professionals:

- Use Figure 1 (lower 48 states) or Figure 2 (Alaska and Hawaii) to determine which lands were reviewed for overlap with the range of pollinators of conservation concern.
- If included on the map, use Tables 3 (federally listed species), 4 (species designated as proposed or candidates for federal listing), 5 (petitioned species), and 7 (birds of conservation concern) to determine if the lands managed are within the range of pollinators of conservation concern.
- If within the range of pollinators or conservation concern, read Section 1 to determine next steps, and consult Appendix A for species range maps and profiles.
- Review Section 1.E and the monarch butterfly maps, tables and profile in Appendix A for information on monarch butterfly biology and conservation.
- Incorporate management actions in this *Reference Guide* and Appendix A in development and implementation of Integrated Natural Resource Management Plans (INRMPs) for Air Force lands where pollinators of conservation concern are present.

Section 2: Natural resource and pest management professionals:

- Read Section 2.A for information on the food and habitat needs of pollinators.
- Read the Section 2.B subsections on land management practices used on your lands to learn how practices can be modified to promote pollinator conservation.
- Identify areas for pollinator conservation in INRMPs and use information in Section 2 to develop and implement management practices.
- If habitat restoration or landscaping projects are planned, use the maps in Figures 4 (lower 48 states) and 5 (Alaska and Hawaii) to determine the ecoregion where the land is located, then use Appendix B, Section 1 (Appendix B-1) to find lists of native plants beneficial to pollinators.
- Read Appendix B, Section 2 (Appendix B-2) for supplemental information on planting.

Section 3: Pest management professionals:

- Read Section 3 for information on how to effectively control pests while reducing pesticide use and the adverse impacts of pest control to pollinators.
- Utilize information in Section 3 to develop and implement Installation Pest Management Plans (IPMPs) for areas where pollinator conservation is a goal.

Section 3: Natural resource management professionals:

- Read highlight boxes in Section 3 for considerations on pest management options to facilitate coordination with IPMP preparation.

Section 4: Natural resource and pest management professionals:

- Read Section 5 to learn how to plan, implement and evaluate education or outreach to those in the Air Force community whose support or assistance is needed to fund or implement pollinator conservation measures.
- Use the websites provided in Section 4.A.2 and 4.B to find factsheets and brochures about pollinator conservation that can be used for education and outreach programs.

Section 5: Natural resource management professionals:

- Read Section 5.A when the range of a species extends beyond Air Force lands.
- Read Section 5.A when there is a large-scale project that would benefit from collaboration with an outside organization.
- Read Section 5.B to learn about two sources of DoD funding that can provide support for pollinator conservation work in partnership with others.

ACRONYMS

AFB = Air Force Base
AFCEC = Air Force Civil Engineer Center
AFI = Air Force Instruction
AFPMB = Armed Forces Best Management Board
AFR = Air Force Range
AFS = Air Force Station
ARS = Agricultural Research Service
AS= Air Station
BASH = Bird/Wildlife Aircraft Strike Hazard
BCC = Bird of Conservation Concern
BCI = Bat Conservation International
Bti = Bacillus thuringiensis var. israelensis
CABI = Centre for Agriculture and Biosciences International
CCA = Candidate Conservation Agreement
CDC = Centers for Disease Control and Prevention
CEC = Commission for Environmental Cooperation
CEQ = Council on Environmental Quality
DENIX = DoD Environment, Safety and Occupational Health Network and Information Exchange
DoD = Department of Defense
DOI = U.S Department of the Interior
DRMO = Defense Reutilization and Marketing Office
ECOS = Environmental Conservation Online System
EPA = Environmental Protection Agency
ESA = Endangered Species Act of 1973, as amended
ETPBR LCC = Eastern Tallgrass Prairie and Big Rivers Landscape Conservation Cooperative
FS = Forest Service
Ft = Fort
FWCA = Fish and Wildlife Conservation Act, as amended in 1988
GEM = Golf Course Environmental Management
GRIP = Grassland Restoration Incentive Program
HMN = Hummingbird Monitoring Network
INRMP = Integrated Natural Resource Management Plans
IPM = integrated pest management
IPMP = Installation Pest Management Plan
JB=Joint Base
JBSA = Joint Base San Antonio
JV = Joint Venture
LCC = Landscape Conservation Cooperative

MAF = Master Address File (MAF)
MTA = Missile Tracking Annex
MTDB = MAF/TIGER Database
Mtn = Mountain
MBJV = Migratory Bird Joint Venture
MBTA = Migratory Bird Treaty Act
mcg = microgram
MJV = Monarch Joint Venture
MOU = Memorandum of Understanding
NAPPC = North American Pollinator Protection Campaign
NEEF = National Environmental Education Foundation
NPLD = National Public Lands Day
NRC = National Research Council
NRCS = Natural Resource Conservation Service
P2 = Pollinator Partnership
PIF = Partners in Flight
RA = Recreation Area
RED = Reregistration Eligibility Decision
REPI = Readiness and Environmental Protection Integration Program
ROWs = rights of way
SIT = Sterile insect technique
SWAP = State Wildlife Action Plan
STS = Satellite Tracking Station
TIGER = Topologically Integrated Geographic Encoding and Referencing
UC = University of California
USDA = U.S. Department of Agriculture
USFWS = U.S. Fish and Wildlife Service
USFWS ES Office = USFWS Ecological Services Office
USFWS-HQ-MB = USFWS Headquarters Migratory Bird Program
USGS = U.S. Geological Survey
WHP = Western Hummingbird Partnership

Taylor's checkerspot (*Euphydryas editha taylori*), an endangered butterfly found in Oregon and Washington (photo: Ted Thomas/USFWS CC BY-NC 2.0)

CONTENTS

EXECUTIVE SUMMARY

This *U.S. Air Force (Air Force) Pollinator Conservation Reference Guide* (*Reference Guide*) provides technical information and resources for implementing the *U.S. Air Force Pollinator Conservation Strategy* consistent with Air Force mission and available funding. The *Reference Guide* builds on documents, such as Pollinator-Friendly Best Management Practices for Federal Lands, released under the Presidential Memorandum *Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators* (June 20, 2014) (Presidential Memo). The *Reference Guide* is part of a larger project that includes development of a strategy and training to support the efforts of Air Force personnel to conserve pollinators. The *Reference Guide* and other project documents were developed collaboratively by the U.S. Fish and Wildlife Service and Air Force Civil Engineer Center. The project was funded by the Air Force under the Sikes Act, as amended (16 U.S.C. 670a-670f).

Pollinators in the United States include most bees and some bats, birds, butterflies, moths, flies, beetles, and other insects. These animals play a crucial role in plant reproduction, and are critical to maintaining diverse and healthy ecosystems. Pollinators aid reproduction in over 75% of flowering plants, resulting in the production of seeds and fruits that provide food to many animals. Pollinators contribute significantly to the U.S. economy. For example, in 2010, it was estimated that insect pollinators contributed approximately $29 billion to the value of agricultural crops. Recently there have been notable declines in a variety of pollinators, including honey bees (*Apis mellifera*) and certain bumble bees, butterflies, hummingbirds, and bats in the United States. Causes of decline include: habitat loss, fragmentation, and alteration; "pathogen spillover"; interspecific competition among bees; changes in plant community composition with the spread of invasive plants; genetically modified crops; non-synchronous changes in pollinator and plant phenology; and pesticide use.

Proactive conservation of declining pollinator species may help reduce the likelihood of future listings under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA), and associated regulatory requirements. Conservation of pollinators supports the Air Force mission by helping to maintain diverse healthy ecosystems that provide a variety of habitats for realistic testing and training exercises. Pollinator conservation may also require less active management and reduce operational costs for improved areas maintenance; enhance the quality of life for Air Force staff and their families; and offer opportunities for partnerships, community-based activities, and outdoor education.

Pollinators are a broad group of species with varying legal protections. Pollinators protected by ESA and/or the Migratory Bird Treaty Act (16 U.S.C. 703-712) have the highest level of protection. Additional pollinators are protected by specific states and/or landowners. The Presidential Memo encompasses all pollinators. Compliance with existing laws, regulations, and policies encompassing pollinators is essential to sustaining the Air Force mission.

Section 1 provides a process for addressing pollinators of conservation concern, including those listed as endangered or threatened under ESA; proposed species or candidates for listing under ESA; designated under Fish and Wildlife Conservation Act as Birds of Conservation Concern; and monarch butterflies. These species need special attention and should be addressed in the installation Integrated Natural Resource Management Plan (INRMP), where they occur. Their presence on Air Force lands should be identified, habitat conditions assessed, and species-specific priorities developed and implemented to assist in their recovery or conservation. Section 1 and Appendix A provide tables and maps that can be used as screening tools to identify pollinators of conservation concern that may occur on particular Air Force lands. Appendix A also includes profiles with specific management recommendations for each of the pollinator species of conservation concern whose range overlaps Air Force lands.

Section 2.A provides information about the habitat and food needs for the major groups of pollinators. A key requirement for pollinators is abundant, diverse native flowering plants available throughout their active season. Pollinators also need sites for nesting or larval development and overwintering. For some pollinators this means specific plant species, while others only need undisturbed, open soil; downed logs, or plants with stems with hollow or soft, spongy centers; trees or bushes; or caves. Identifying areas for pollinator conservation and specific on-the-ground measures and projects to benefit pollinators in INRMPs is critical to pollinator habitat conservation.

Land management practices can be beneficial or harmful to pollinator conservation depending on how they are implemented. Section 2.B provides considerations for pollinator conservation for common land management practices. The information in Section 2, combined with the native flowering plant lists provided in Appendix B, Section 1 (Appendix B-1) can be used to select appropriate plants for pollinator conservation projects. Supplemental information on planting is provided in Appendix B, Section 2 (Appendix B-2). Throughout Section 2, emphasis is placed on implementing practices to maintain or increase native nectar sources and nesting sites and materials, reduce soil disturbance, eliminate or control invasives, and reduce pesticide use. Managers need to consider the timing of land management activities relative to pollinator life cycles and the extent of the habitat being altered at any one time to avoid harm to onsite pollinators. Properly designed management actions can benefit a wide variety of pollinators and the entire ecosystem. Over the long-term these actions may even reduce maintenance costs.

Section 3 provides information on methods to: (1) effectively control pests while reducing pesticide use and (2) reduce the adverse impacts of pesticide use on pollinators. This information can be used to prepare Installation Pest Management Plans (IPMPs) and coordinate IPMPs and INRPMs. Pesticides are one factor that contributes to pollinator declines so their use should be eliminated or reduced in areas where pollinator conservation is a goal. This section reviews the principles of integrated pest management (IPM), including the importance of monitoring and setting thresholds to determine when pest control is needed. IPM keeps pests under control while minimizing harm to non-targeted species, such as pollinators. Alternatives to pesticides, such as cultural, physical and mechanical methods that achieve management goals, are discussed, and should be used before pesticides. Methods for reducing toxic effects of pesticides to pollinators and exposure of pollinators to pesticides are also discussed.

Section 4 provides information to develop, implement and evaluate educational outreach programs. Natural resource and pest management professionals will need the support of others in

the Air Force community to obtain funding and implement pollinator conservation actions. To accomplish this, they will need to develop informal or formal educational outreach programs and materials. The information in this section will be useful if there are opportunities to educate members of the public visiting the installation or if the cooperation of nearby landowners is needed to provide corridors connecting pollinator populations among multiple landowners.

Section 5.A provides information about multi-organizational partnerships that focus on or include pollinator conservation in their activities. Working with a partnership may be helpful when key habitat for a pollinator of conservation concern is located off-installation, where connecting pollinator populations on an installation to neighboring populations would be beneficial, and when encroachment is an issue. Partnerships can also be a source of data and technical information about pollinators, and funding for research, restoration, or recovery. They can be a valuable partner in educational activities. Section 5.B provides information on two source of Department of Defense funding that can be used for pollinator conservation work in partnership with others.

Native rose verbena (*Verbena canadensis*) was added to landscaping at McConnell Air Force Base in Kansas to provide food for pollinators
(photo: Laura Mendenhall/USFWS)

INTRODUCTION

This section provides background information on the purpose of this document, pollinators, their importance and why pollinator conservation is important to the U.S. Air Force (Air Force).

Increasing attention has been placed on pollinator conservation in recent years with well-documented declines in highly visible pollinators, such as North American monarch butterflies (*Danaus plexippus plexippus*) and honey bees (*Apis mellifera*). Pollinators are a key component of ecological integrity. The Air Force Civil Engineer Center (AFCEC) and U.S. Fish and Wildlife Service (USFWS) partnered to provide resources for Air Force personnel working to sustain the military mission and ecological integrity on Air Force lands. This cooperation, directed by the Sikes Act and other authorities, supports the mission of the Air Force by sustaining military readiness, and benefits USFWS in its mission to conserve, protect and enhance fish, wildlife and plants, and their habitats. The primary objective of Air Force natural resources programs is to sustain, restore and modernize natural infrastructure to ensure operational capability and no net loss in the capability of Air Force lands to support the military mission of the installation.

This section provides the background information necessary for understanding and addressing pollinator declines. Understanding the vast array of species that pollinate native plants and crops and their important role in maintaining native ecosystems will provide a basis for determining what areas are suitable for pollinator conservation. Knowledge of the threats to pollinator populations is necessary for addressing those threats and seeking opportunities to implement conservation measures. Finally, recognition of the administrative and regulatory protections afforded pollinators is important in assuring compliance with existing regulations and policies.

Ruby-throated Hummingbirds (*Archilochus colubris*) are found in the eastern U.S.
(photo: Steve Maslowski/USFWS)

PURPOSE OF THIS REFERENCE GUIDE

HIGHLIGHTS

- This *U.S. Air Force (Air Force) Pollinator Conservation Reference Guide* (*Reference Guide*) provides information to supplement the *U.S. Air Force Pollinator Conservation Strategy* (*Strategy*) developed jointly by AFCEC and USFWS
- The vision of the *Strategy* is to: sustain the Air Force mission and ecological integrity on Air Force lands; implement pollinator conservation practices to enhance habitat; and broaden awareness among Air Force personnel
- Goals are focused on:
    - Conserving pollinators of conservation concern
    - Conserving pollinator habitat
    - Reducing pesticide use and adverse impacts
    - Promoting pollinator conservation through education and outreach
    - Developing pollinator conservation partnerships off Air Force lands
- The *Reference Guide* includes two Appendices – A, Species maps and profiles; B, Restoration and landscaping information, including planting lists for each Ecoregion in the United States

This *U.S. Air Force (Air Force) Pollinator Conservation Reference Guide* (*Reference Guide*) provides technical information and resources for implementing the *U.S. Air Force Pollinator Conservation Strategy* (*Strategy*) consistent with Air Force mission and available funding. This *Reference Guide* was developed to supplement existing agency policies, guidance, instructions, and business rules, and is informed by such.

The *Strategy* lays out a strategic vision, goals and objectives for the Air Force to achieve pollinator conservation on Air Force lands. Both documents address one aspect of natural resource management, pollinator conservation. The *Reference Guide* builds on documents, such as *Pollinator-Friendly Best Management Practices for Federal Lands*, released under the Presidential Memorandum *Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators* (June 20, 2014) (Presidential Memo). The *Reference Guide* is part of a larger project that includes development of a strategy and training to support the efforts of Air Force personnel to conserve pollinators.

The *Reference Guide* provides the technical information to support the vision from the *Strategy* to:

> Sustain the Air Force mission and ecological integrity on Air Force installations by implementing management practices that support pollinators and enhance their habitat, especially those with regulatory protections. Broaden awareness among Air Force personnel of the plight of pollinators and measures needed to improve their status.

Each Section of the *Reference Guide* supports one of the five specific goals from the *Strategy:*

Section 1, Conserving Pollinator Species of Conservation Concern supports Goal 1: Conserve pollinator species of conservation concern in cooperation with U.S. Fish and Wildlife Service, the state fish and wildlife agencies, and other partners using Integrated Natural Resource Management Plans (INRMPs) and other tools.

Section 2, Conserving and Enhancing Pollinator Habitat supports Goal 2: Conserve and enhance pollinator habitat on Air Force installations where it is compatible with the mission using INRMPs and other tools.

Section 3, Reducing Pesticide Use and Adverse Impacts of Pest Control supports Goal 3: Reduce pesticide use and adverse impacts of pest control on pollinators through use of INRMPs and Installation Pest Management Plans (IPMPs).

Section 4, Promoting Pollinator Conservation through Education and Outreach supports Goal 4: Promote pollinator conservation through education and outreach.

Section 5, Partnerships for Pollinator Conservation Off-Installation supports Goal 5: Develop partnerships for pollinator conservation off-installation to lessen regulatory burdens by aiding the recovery of listed pollinators and preventing further pollinator declines.

The *Reference Guide* Appendices provide:

Appendix A, Species maps and profiles provides species-specific information for species of conservation concern. Species of conservation concern is defined for this project as species listed as endangered or threatened under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq*.) (ESA), species proposed or candidates for listing under ESA, birds designated as Birds of Conservation Concern (BCCs) under the Fish and Wildlife Conservation Act, as amended in 1988 (FWCA) (16 U.S.C. 2901-2911), and monarch butterflies (*Danaus plexippus plexippus*)

Appendix B, Restoration and landscaping information provides descriptions and planting lists for each Ecoregion in the United States. Ecoregions follow those mapped by Bailey (Bailey, 1995) for use by land managers. Information on preparing a site for planting (vegetation removal) and planting techniques is also included.

WHAT ARE POLLINATORS?

HIGHLIGHTS

- Pollinators, including, bees and some bats, birds, butterflies, moths, flies, beetles, and other insects play a crucial role in plant reproduction
- Bees are the most important pollinators in temperate areas
- Flies are important in cool, wet climates
- Bats can be important in deserts
- All pollinators are not able to pollinate all plants

Pollinators in the United States include most bees and some bats, birds, butterflies, moths, flies, beetles, and other insects. Pollinators play a crucial role in plant reproduction by moving pollen grains from a flower's male parts (anthers) to the female part (stigma) of the same species, where, if fertilization is successful, it can result in the production of fruits and seeds. Plants produce nectar to attract pollinators. As the pollinator moves from flower to flower collecting nectar, it also moves pollen from flower to flower. Some pollinators, primarily bees, also actively collect and feed on pollen.

Bees are the most important pollinators in temperate areas. Flies are important pollinators in cool, wet climates like alpine areas and the Arctic tundra. Bats and the white-winged dove (*Zenaida asiatica*) can be important pollinators of desert plants. Beetles, wasps and ants are less important pollinators than other insects, but there are a few plants that are pollinated mainly or solely by these species (Borror, et al., 1981; Evans, 1984; Hickman, 1974; Marshall, 2012; National Research Council (NRC), 2007; Oldroyd, 1964).

Plants and their pollinators have co-evolved over time, and as a result all pollinators are not able to pollinate all plants. The pollinator needs to come into contact with the pollen when feeding on nectar to be effective. While the flowers of some plants are accessible to many pollinators, others are only accessible to a limited suite of pollinators. Plants with a nectar source deep within the flower require pollinators with a long tongue or proboscis (mouthpart of butterflies and moths). Some pollinators must have a place to land while feeding on nectar (e.g., butterflies), while others (e.g., hawk moths and hummingbirds) can hover next to the flower. Pollinator preference for a particular color or scent may drive which species of plant they pollinate. Other plants have pollen within a structure that needs to be shaken to release the pollen. These are pollinated by bees (notably bumble bees) which contract their flight muscles, shaking their body, and the flower to release the pollen. This is called "buzz pollination" because of the sound produced by the muscle contractions (Barth, 1991; Evans, 1984).

WHY FOCUS ON POLLINATORS?

HIGHLIGHTS

- Pollinators are critical to maintaining diverse and healthy ecosystems
- Pollinators contribute billions of dollars to the U.S. economy through services to crops
- There have been declines in pollinators, including certain bumble bees, butterflies, hummingbirds, bats, and honey bees
- Declines are attributed to habitat loss, fragmentation, and alteration; disease; the spread of invasive plants and Africanized bees; genetically modified crops; non-synchronous changes in pollinators and plants; and pesticide use

Pollinators are critical to maintaining diverse and healthy ecosystems, aiding reproduction in over 75% of flowering plants (NRC, 2007). Pollination results in the production of seeds and fruits that provide food to many animals. Pollinators also contribute to the U.S. economy. In 2010, it was estimated that insect pollinators contributed approximately $29 billion to the value of agricultural crops (Calderone, 2012). In recent years, there have been notable declines in a variety of pollinators, including certain bumble bees, butterflies, hummingbirds, and bats, as well as honey bees, in the United States (NRC, 2007). These significant losses precipitated the President to issue a memorandum *Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators* on June 20, 2014 (Presidential Memo). This Presidential Memo focused on development of a federal strategy to promote pollinator health. In the memorandum he called upon the Department of Defense (DoD) to: "consistent with law and the availability of appropriations, support habitat restoration projects for pollinators, and shall direct military service installations to use, when possible, pollinator-friendly native landscaping and minimize use of pesticides harmful to pollinators through integrated vegetation and pest management practices."

The decline of wild pollinators is generally attributed to: habitat loss, fragmentation, and alteration; and "pathogen spillover" (Grozinger and Evans, 2015; NRC, 2007). Pathogen spillover occurs when cultivated nonnative species interact with native species and introduce pathogens into native populations. Other factors that could contribute to declines include interspecific competition among bees, changes in plant community composition with the spread of invasive plants, genetically modified crops (e.g., potential mortality from *Bt* corn[1] or loss of nectar and host plants through increased herbicide use with herbicide tolerant crops), non-synchronous changes in pollinator and plant phenology (especially timing of flowering), and pesticide use. Proactive conservation of declining pollinator species may help reduce the likelihood of future listings under ESA, and associated regulatory requirements.

[1] Bt corn is corn that has been genetically modified to include a gene from Bacillus thuringiensis that produces a protein toxic to Lepidoptera (butterflies and moths), such as the European corn borer.

Declines in managed pollinators have been attributed to a variety of causes. Honey bee declines are attributed to parasites, pathogens, improper pesticide use, and in some areas, encroachment of Africanized bees (NRC, 2007). Other bee species managed for crop pollination, such as leafcutter bees and bumble bees, are vulnerable to disease (NRC, 2007). Grozinger and Evans (2015) notes the continued decline of pollinators and attributes declines to anthropogenic chemicals (pesticides and other chemicals in their formulations), deficient food sources, and parasites and pathogens.

Flower fly (*Ipomopsis polyantha*) (photo: Alicia Langton/USFWS)

WHY IS POLLINATOR CONSERVATION IMPORTANT TO THE AIR FORCE?

HIGHLIGHTS

- Compliance with laws protecting specific pollinators (e.g., under ESA or the Migratory Bird Treaty Act (MBTA) is essential to sustaining the Air Force mission
- All pollinators are afforded consideration under the Presidential Memo and the Office of the Under Secretary of Defense memorandum directing Assistant Secretaries to use native landscaping and minimize pesticides use in sensitive habitats
- Conservation of pollinators supports diverse healthy ecosystems for overflights and training missions, buffers for local communities, and long-term sustainability of our natural heritage
- Pollinator conservation reduces operational and maintenance costs for improved area management, enhances quality of life for Air Force personnel and their families, and provides opportunities for recreation, education and partnerships
- DoD has emphasized pollinator conservation through $2 million in project funding support and partnerships with Bat Conservation International (BCI) and Pollinator Partnership (P2) focused on pollinator conservation

Compliance with existing laws, regulations, and policies encompassing pollinators is essential to sustaining the Air Force mission. Some pollinators have legal protections. Pollinators protected by ESA and/or the Migratory Bird Treaty Act (16 U.S.C. 703-712) (MBTA) have the highest level of protection. These protections are discussed in Section 1.B and 1.D, respectively. Additional pollinator species are protected by specific states and/or landowners.

All pollinators are afforded consideration under the Presidential Memo calling for creating a federal strategy to promote pollinator health. They are also covered by a memorandum issued by the Office of the Under Secretary of Defense to the Assistant Secretaries on September 5, 2014 (Under Secretary of Defense Memo). This memorandum directed the Assistant Secretaries to use current best management practices to protect pollinators and their habitats, including "when possible and to the extent practicable, use native landscaping and minimize the use of pesticides in sensitive habitats …"

Conservation of pollinators supports the Air Force mission by helping to maintain diverse healthy ecosystems. These natural landscapes provide realistic conditions for overflights and training missions and serve as buffers for local communities. Healthy, diverse native plant communities require less active management and are more resilient to human and naturally occurring stressors (Pollinator Health Task Force, 2015). Implementing pollinator conservation can enhance ecosystems under Air Force stewardship, and ensure the long-term sustainability of our nations' natural heritage, while supporting the military mission.

Pollinator conservation measures can further benefit the Air Force by reducing operational and maintenance costs for management of improved areas. Examples include reduced costs for: (1) long-term maintenance, with the use of native plants that are better adapted to their local

environments than nonnative ornamentals; (2) pest control, with reduced reliance on pesticides; and (3) mowing, as frequency is reduced. Reduced mowing schedules will also reduce carbon emissions.

Conserving pollinators can enhance the morale and welfare of Air Force personnel and their families by providing a variety of outdoor recreation opportunities. Pollinators, such as butterflies, moths and hummingbirds, as well as the plants that provide them nectar and pollen, are great subjects for nature-watching and photography and can enhance other outdoor activities, such as hiking and camping. Pollinator conservation also offers opportunities for partnerships, community-based activities, and outdoor education.

The importance of pollinator conservation to the Air Force can be seen, in part, through funding support for pollinator conservation by both the Air Force and DoD over the past 15 to 20 years. Between 2009 and 2014, over $2 million (most from the Legacy Program) funded 240 National Public Lands Day projects benefitting pollinators (Peter Boice, DoD Legacy Resource Management Program, National Public Lands Day DoD Sites, FY1999-2014 table). Among these were projects completed by over 30 Air Force installations.

DoD has emphasized the importance of pollinator conservation to the military services by developing partnerships to support their conservation. DoD has Memorandums of Understanding (MOUs) with Bat Conservation International (BCI) and Pollinator Partnership (P2). The MOU with BCI "establishes a policy of cooperation and coordination between DoD and BCI to identify, document and maintain bat populations and their habitats on DoD installations"[2] (signed Oct 2006, renewed Dec. 2011). The MOU with P2 is "to establish a framework for cooperative programs that promote the conservation and management of pollinators, their habitats and associated ecosystems" (signed February 9, 2015). The MOU states that this framework is important to "ensure that pollinator management activities are incorporated where practicable, into installation Integrated Natural Resource Management Plans (INRMPs) and practices." Conservation of pollinators by Air Force alone or in collaboration with groups such as BCI and P2 supports these DoD initiatives. This *Reference Guide* provides specific pollinator conservation measures which can be incorporated into INRMPs and implemented by the Air Force.

[2] While most bats in the U.S. are not pollinators, there are several species (e.g., lesser long-nosed bat, *Leptonycteris curasoae yerbabuenae*) that are.

Blue-throated Hummingbird (*Lampornis clemenciae*), a BCC (photo: Alan Schmierer/ CC0 1.0)

SECTION 1: CONSERVING POLLINATOR SPECIES OF CONSERVATION CONCERN

This section provides a process for addressing pollinators of conservation concern. This section combined with Appendix A provides tables and maps that can be used as screening tools to identify pollinators of conservation concern that may occur on particular Air Force lands. These species should be included in planning documents and specific conservation actions should be developed, if they are found on Air Force lands. Appendix A includes profiles for each of the pollinator species of conservation concern whose range overlaps Air Force lands. The profiles provide a starting point in preparation for contacting the local USFWS office for further assistance developing a conservation strategy.

While there is general concern about pollinator population declines, some species have already declined to such an extent that their very survival as a species is approaching or has already reached endangered or threatened status. These species, in particular, need special attention. Their presence on Air Force lands should be identified, habitat conditions assessed, and species-specific priorities developed and implemented to assist in their recovery. For the purposes of this *Reference Guide*, the term "pollinator species of conservation concern" refers to monarch butterflies or pollinators that are: listed as endangered or threatened under ESA; proposed or candidates for listing under ESA; or birds designated under FWCA as BCCs. Monarch butterflies are included as a pollinator species of conservation concern because they have declined significantly over the past two decades. In the future, as new information becomes available and conditions change, other pollinator species may be included as a pollinator species of conservation concern. These species should be addressed in each installation's INRMP.

Identifying which, if any, pollinator species of conservation concern are located on particular Air Force lands is the first step in addressing their conservation. To assist with this task, this *Reference Guide* provides tables and maps of federally listed pollinators and birds of conservation concern that may occur on Air Force lands. Maps and conservation information are also provided for the monarch butterfly since its range encompasses most of the continental U.S. In addition, this section outlines the regulatory requirements for listed species and migratory birds and provides a process for addressing pollinators of conservation concern.

SECTION 1. A. AIR FORCE LANDS INCLUDED IN REFERENCE GUIDE MAPS

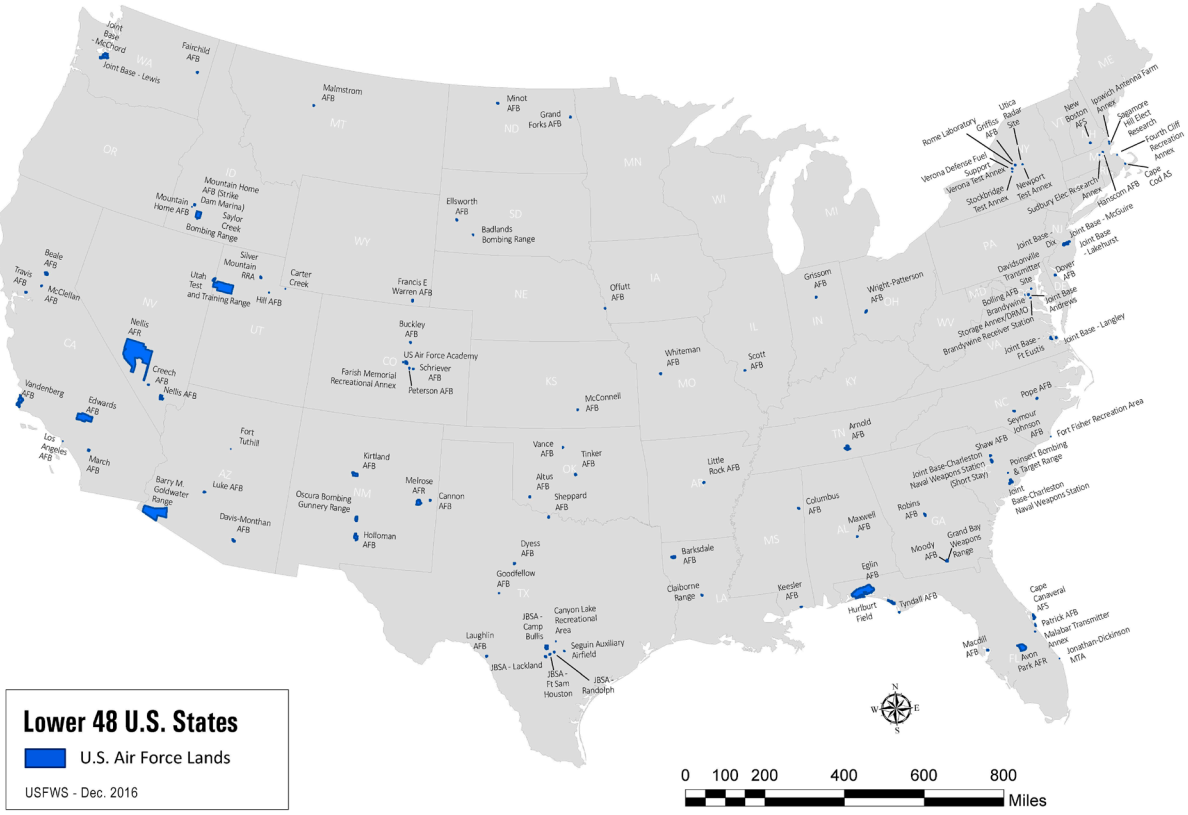
HIGHLIGHT

- Figures 1 (lower 48 states) and 2 (Alaska and Hawaii) show the Air Force lands screened by USFWS for overlap with the range of pollinators that are federally listed or designated a BCC.

AFCEC worked with USFWS to develop a list of Air Force lands to screen for overlap with the range of pollinators that are federally listed or designated a BCC. In general, installations that are required to prepare an INRMP and recreation areas are included. Lands included are shown in Figures 1 (lower 48 states) and 2 (Alaska and Hawaii). USFWS used publicly available shapefiles to determine Air Force boundaries[3].

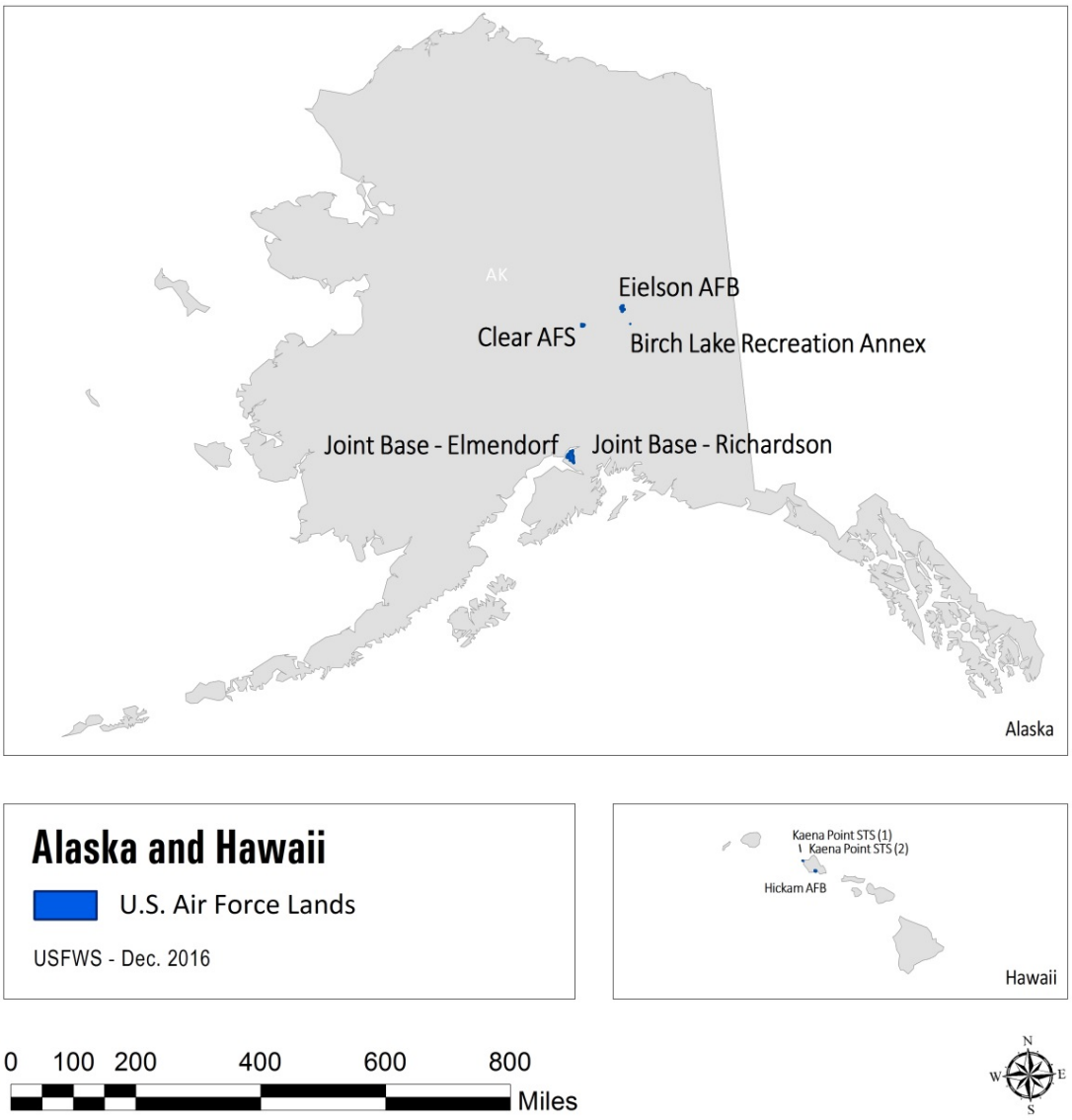
[3] Based on a list provided by AFCEC, boundaries for Air Force lands were selected from the Census Topologically Integrated Geographic Encoding and Referencing (TIGER)/Line Shapefile, 2015, nation U.S., Military Installation Shapefile, the Federal Lands of the United States map layer and boundaries (feature class) provided by Air Force. This dataset does not display a complete geospatial location of all Air Force installations. The TIGER/Line shapefiles and related database files (.dbf) are an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File (MAF)/TIGER Database (MTDB). The MTDB represents a seamless national file with no overlaps or gaps between parts. The military installation boundaries represent the updates the Census Bureau made in 2012 in collaboration with DoD. Only areas of 640 acres or more are included. There may be private inholdings within the boundaries of Federal lands in this map layer. This is a revised version of the January 2005 map layer.

Figure 1: Air Force lands reviewed for overlap with the range of pollinators that are federally listed or designated a BCC: Lower 48 states



AFB = Air Force Base; AFS = Air Force Station; AS = Air Station; DRMO = Defense Reutilization and Marketing Office; Ft = Fort; JBSA = Joint Base San Antonio; MTA = Missle Tracking Annex

Figure 2: Air Force lands reviewed for overlap with the range of pollinators that are federally listed or designated a BCC: Alaska and Hawaii



STS = Satellite Tracking Station

SECTION 1. B. ENDANGERED AND THREATENED POLLINATORS

1. B.1. Regulatory and policy protections – federally endangered and threatened species

HIGHLIGHTS

- Pollinators listed under ESA are protected from take and require consultation with USFWS if projects may affect them
- ESA calls for federal agencies to assist in the conservation of federally listed species

RELEVANT SECTION OF AIR FORCE INSTRUCTION (AFI)

- AFI 32-7064, Chapter 8: INRMPs must provide an ecosystem management strategy that provides for the protection and recovery of federally endangered and threatened species; installations are required to conduct a basic reconnaissance survey to determine the presence of any federally endangered, threatened or candidate species

Pollinators listed under ESA are afforded more protection than other pollinators that are not listed under ESA. They are protected from take. Take is defined under ESA as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct. Seventy-two pollinators found in the United States and its territories are listed under ESA as endangered or threatened (including three species listed due to similarity of appearance) as of October 26, 2017. Tables 1 (mammals and birds) and 2 (insects) provide a list of pollinators that are federally listed as endangered or threatened. Among the pollinators protected by ESA are 4 bats; 22 birds; 36 butterflies (including 3 listed due to similarity in appearance), moths, and skippers; 8 bees; 1 beetle; and 1 fly.

Installations are required to conduct "a basic reconnaissance survey to determine the presence of any federally listed Threatened, Endangered or Candidate species on an installation" with methods, scope, and species considered determined after consultation with USFWS (Air Force Instruction 32-7064, *Integrated Natural Resource Management Plans* (AFI 32-7064), Chapter 8). Additional reconnaissance surveys are required when a newly listed species may occur on the installation. Resurveys may be required in certain situations (e.g., if stipulated in a Biological Opinion, Recovery Plan or INRMP). If a federally listed species may be affected by a federally funded or authorized project, consultation with USFWS is required under Section 7(a) (2) of ESA. Furthermore, Section 7(a) (1) of ESA calls upon Federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species. . ." In support of Section 7 (a) (1) of ESA, INRMPs must provide an ecosystem management strategy that provides for protection and recovery of federally listed species (AFI 32-7064, Chapter 8).

Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), an endangered species found in Arizona and New Mexico (photo: Bill Radke/USFWS)

I'iwi (*Drepanis coccinea*), a threatened species found in Hawaii (photo: Noah Kahn/USFWS)

Table 1: Pollinator species protected by ESA: mammals and birds

Species Group	Species	Status[4]	States/Territories with known occurrences[5]
Mammals	Lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*)[6]	E	AZ, NM
Mammals	Little Mariana fruit bat (*Pteropus tokudae*)	E	GU
Mammals	Mariana fruit bat (*Pteropus mariannus mariannus*)	T	GU, MP
Mammals	Mexican long-nosed bat (*Leptonycteris nivalis*)	E	NM, TX
Birds	'Akeke'e or Kaua'i 'Akepa (*Loxops caeruleirostris*)	E	HI
Birds	'Akiapola'au (*Hemignathus wilsoni*)	E	HI
Birds	'Akikiki (*Oreomystis bairdi*)	E	HI
Birds	'Akohekohe or Crested Honeycreeper (*Palmeria dolei*)	E	HI
Birds	'Alala or Hawai'ian Crow (*Corvus hawaiiensis*)	E	HI
Birds	Bridled White-eye (*Zosterops conspicillatus conspicillatus*)	E	GU
Birds	Hawai'i 'Akepa (*Loxops coccineus*)	E	HI
Birds	Hawai'i Creeper (*Loxops mana*)[7]	E	HI
Birds	'I'iwi (*Drepanis coccinea*)[8]	T	HI
Birds	Kaua'i 'Akialoa (*Akialoa stejnegeri*)	E	HI
Birds	Kaua'i Nukupu'u (*Hemignathus hanapepe*)	E	HI
Birds	Kaua'i 'O'o (*Moho braccatus*)	E	HI
Birds	Ma'oma'o or Mao (*Gymnomyza samoensis*)	E	AS
Birds	Maui 'Akepa (*Loxops ochraceus*)	E	HI

[4] E=Endangered and T = Threatened

[5] Locations use standard two letter abbreviations adopted by the U.S. Postal Service found at: https://pe.usps.com/text/pub28/28apb.htm

[6] USFWS proposed delisting this species on January 6, 2017 (82 FR 1665); a final decision was not made prior to completion of this report.

[7] Listed in some locations by its former scientific name, *Oreomystis mana.*

[8] Listed in some locations by its former scientific name, *Vestiaria coccinea*.

Species Group	Species	Status[4]	States/Territories with known occurrences[5]
Birds	Maui Nukupu'u *(Hemignathus affinis)*	E	HI
Birds	Maui Parrotbill *(Pseudonestor xanthophrys)*	E	HI
Birds	Moloka'i Creeper or Kakawahie *(Paroreomyza flammea)*	E	HI
Birds	O'ahu 'Alauahio or O'ahu Creeper *(Paroreomyza maculata)*	E	HI
Birds	'O'u *(Psittirostra psittacea)*	E	HI
Birds	Palila *(Loxioides bailleui)*	E	HI
Birds	Po'ouli *(Melamprosops phaeosoma)*	E	HI
Birds	Rota Bridled White-eye (*Zosterops rotensis*)	E	MP

Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*), a threatened species found in California (Photo: John Katz and Joe Silveria/USFWS)

Table 2: Pollinator species protected by ESA: insects

Species group	Species	Status	States/Territories with known occurrences
Bees	Anthricinan yellow-faced bee (*Hylaeus anthracinus*)	E	HI
Bees	Assimulans yellow-faced bee (*Hylaeus assimulans*)	E	HI
Bees	Easy yellow-faced bee (*Hylaeus facilis*)	E	HI
Bees	Hawaiian yellow-faced bee (*Hylaeus kuakea*)	E	HI
Bees	Hawaiian yellow-faced bee (*Hylaeus longiceps*)	E	HI
Bees	Hawaiian yellow-faced bee (*Hylaeus mana*)	E	HI
Bees	Hilaris yellow-faced bee (*Hylaeus hilaris*)	E	HI
Bees	Rusty patched bumble bee (*Bombus affinis*)	E	IL, IN, IA, ME, MD, MA, MN, NC, OH, PA, TN, VA, WI
Beetles	Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	T	CA
Flies	Delhi Sands flower-loving fly (*Rhaphiomidas terminatus abdominalis*)	E	CA
Butterflies	Bartram's hairstreak butterfly (*Strymon acis bartrami*)	E	FL
Butterflies	Bay checkerspot (*Euphydryas editha bayensis*)	T	CA
Butterflies	Behren’s silverspot (*Speyeria zerene behrensii*)	E	CA
Butterflies	Callippe silverspot (*Speyeria callippe callippe*)	E	CA
Butterflies	Cassius blue (*Leptotes cassius theonus*) [Listed due to similarity in appearance (SIA) to Miami blue.]	T	FL[9]
Butterflies	Ceraunus blue (*Hemiargus ceraunus antibubastus*) [Listed due to SIA to Miami blue.]	T	FL[6]
Butterflies	El Segundo blue (*Euphilotes battoides allyni*)	E	CA

[9] Range extends beyond Florida, but listed as threatened in coastal south and central Florida due to similarity of appearance to Miami blue butterfly.

Species group	Species	Status	States/Territories with known occurrences
Butterflies	Fender's blue (*Icaricia icarioides fenderi*)	E	OR
Butterflies	Florida leafwing (*Anaea troglodyta floridalis*)	E	FL
Butterflies	Karner blue (*Lycaeides melissa samuelis*)	E	IL, IN, MI, MN, NH, NY, OH, WS
Butterflies	Lange's metalmark (*Apodemia mormo langei*)	E	CA
Butterflies	Lotis blue (*Lycaeides argyrognomon lotis*)	E	CA
Butterflies	Mariana eight-spot butterfly (*Hypolimnas octocula mariannensis)*	E	GU, MP
Butterflies	Mariana wandering butterfly (*Vagrans egistina)*	E	GU, MP
Butterflies	Miami blue (*Cyclargus thomasi bethunebakeri*)	E	FL
Butterflies	Mission blue (*Icaricia icarioides missionensis*)	E	CA
Butterflies	Mitchell's satyr (*Neonympha mitchellii mitchellii*)	E	AL, IN, MI, MS, OH, VA
Butterflies	Mount Charleston blue (*Plebejus shasta charlestonensis*)	E	NV
Butterflies	Myrtle's silverspot (*Speyeria zerene myrtleae*)	E	CA
Butterflies	Nickerbean blue (*Cyclargus ammon*) [Listed due to SIA to Miami blue.]	T	FL[6]
Butterflies	Oregon silverspot (*Speyeria zerene hippolyta*)	T	OR, CA
Butterflies	Palos Verde blue (*Glaucopsyche lygdamus palosverdesensis*)	E	CA
Butterflies	Quino checkerspot (*Euphydryas editha quino*)	E	CA
Butterflies	San Bruno elfin (*Callophrys mossii bayensis*)	E	CA
Butterflies	Schaus swallowtail (*Heraclides aristodemus ponceanus*)	E	FL
Butterflies	Smith's blue (*Euphilotes enoptes smithi*)	E	CA
Butterflies	St. Francis' satyr (*Neonympha mitchellii francisci*)	E	NC
Butterflies	Taylor's checkerspot (*Euphydryas editha taylori*)	E	OR, WA
Butterflies	Uncompahgre fritillary (*Boloria acrocnema*)	E	CO
Moths	Blackburn's sphinx moth (*Manduca blackburni*)	E	HI
Moths	Kern primrose sphinx moth (*Euproserpinus euterpe*)	T	CA

Species group	Species	Status	States/Territories with known occurrences
Skippers	Carson wandering skipper (*Pseudocopaeodes eunus obscurus*)	E	CA, NV
Skippers	Dakota skipper (*Hesperia dacotae*)	T	IA, MN, ND, SD
Skippers	Laguna Mountains skipper (*Pyrgus ruralis lagunae*)	E	CA
Skippers	Pawnee montane skipper (*Hesperia leonardus montana*)	T	CO
Skippers	Poweshiek skipperling (*Oarisma poweshiek*)	E	IA, MI, MN, ND, SD, WS

Karner blue butterfly (*Lycaeides melissa samuelis*), an endangered butterfly found from the Midwest to the Northeast (photo: U.S. Department of Agriculture (USDA), Forest Service (FS))

1. B. 2. Process for addressing federally endangered and threatened pollinators

HIGHLIGHTS

- Use Table 3 to determine which Air Force lands are found within the range of a federally listed pollinator. Refer to Appendix A, Section 1 (Appendix A-1) for a species range map
- For Air Force lands within the range of a federally listed pollinator where a discovery or reconnaissance survey has not been conducted:
    - use the species profile in Appendix A-1 and information in the Recovery Plan and Five Year Status Review to become familiar with the species
    - contact the local USFWS Ecological Services (ES) office regarding the need and techniques for discovery surveys
- If a federally listed pollinator species is found on Air Force lands, then:
    - check with the local USFWS ES office on whether a consultation is needed for any activities in the area
    - review actions and tasks recommended in the Recovery Plan and work with USFWS and others to identify any Air Force can conduct
    - explore partnerships that would be beneficial for recovery, and reduce the burden on Air Force lands
- Include specific recovery actions and tasks for federally listed species found on Air Force lands in the installation INRMP
- Report completed species recovery actions and tasks to USFWS species lead

HELPFUL WEBSITES

- Species information (USFWS Environmental Conservation Online System (ECOS)): http://ecos.fws.gov/ecp/
- USFWS ES office locations: https://www.fws.gov/ecological-services/map/index.html

Table 3 shows which Air Force lands (in Figures 1 and 2) as determined by USFWS, are located within the range of the federally listed pollinator species as of September 30, 2016. Inclusion in Table 3 does not mean that the species presence has been confirmed on the Air Force lands. Inclusion only indicates that the lands occur within the currently defined range of the species. For the species listed in Table 3 (except the yellow-faced bee species), a map of the species range within the U.S. is provided in Appendix A, Section 1 (Appendix A-1). The maps found in Appendix A-1 may not exactly match USFWS Environmental Conservation Online System (ECOS) maps because they have been tailored for this project, while ECOS maps are refined periodically. Table 3 and the maps in Appendix A-1 are not intended to replace consultation for specific projects. The intended use of Table 3 and Appendix A-1 is to identify pollinators where proactive conservation under section 7 (a) (1) of ESA may be appropriate and to provide a starting point for identifying their habitat and potential conservation actions. If species ranges

expand, contract or shift there may be changes in which Air Force lands are located within their range. ESA-listed pollinators possible on Air Force lands may change as new pollinator species are listed under ESA and as others are recovered and delisted.

If Air Force lands are within the range of a federally listed pollinator species, but species surveys have not been conducted in appropriate habitat, the first step is to review the maps and species profiles in Appendix A-1 to become familiar with the species range, habitat, and recovery needs. The profiles in Appendix A-1 provide basic information on the biology, habitat, threats and management recommendations for the species in Table 3. The profile for the two *Hylaeus* species is combined because much of the information available is similar. Additional species information, including listing notices and recovery plans, can be found in ECOS. Review the species recovery plan and the current Five Year Review (both found in ECOS). After reviewing the information in Appendix A-1 and ECOS, contact the local USFWS Ecological Services (ES) office. USFWS ES office staff will either be able to offer advice on the need, appropriate times, and methods for discovery surveys, or provide contact information for the Regional Recovery Coordinator. The Regional Recovery Coordinator can provide the name and contact information for the species recovery lead. Surveys may require consultation if trampling of host plants could cause mortality of immature stages of federally listed species.

Once it has been determined that a federally listed pollinator is present on Air Force lands, coordinate with the local USFWS ES office, as well as state fish and wildlife agencies (if state listed), to determine if consultation under section 7(a)(2) of ESA is needed for Air Force actions. The local USFWS ES will also be able to help determine if there are potential recovery actions or tasks that could be undertaken by the Air Force. Potential recovery actions and tasks could include identifying priority areas on Air Force lands for conservation, conducting additional surveys or habitat assessments, improving habitat quality, or reducing other threats. The species recovery plan will identify specific actions and tasks necessary for recovery of the species.

The maps in Appendix A-1 show federal land ownership within the range of the listed species to facilitate coordination on recovery actions. If other federal agencies have land within the species range, work with the USFWS species lead, state fish and wildlife agencies, and those landowners to determine if it would be beneficial to work in partnership on recovery, and, if so, try to establish a partnership. Recovery actions and tasks undertaken by other landowners or organizations will benefit the species, and may benefit the Air Force mission.

Conservation and recovery actions and tasks being implemented by the Air Force or on Air Force lands should be included in the installation INRMP as part of the ecosystem management strategy providing for the protection and recovery of the species. Report completed species recovery actions and tasks to the USFWS species lead.

Table 3: Air Force lands within the range of federally listed pollinator species

Air Force Lands	State	Dakota skipper	El Segundo blue	Lesser long-nosed bat	Mitchell's satyr	Rusty patched bumble bee[10]	St. Francis' satyr	Taylor's checkerspot	Valley elderberry longhorn beetle	Yellow-faced bees (*Hylaeus anthracinus, H. longiceps*)[11]
Arnold AFB	TN	No	No	No	No	Possible	No	No	No	No
Barry Goldwater Range	AZ	No	No	Yes	No	No	No	No	No	No
Beale AFB	CA	No	No	No	No	No	No	No	Yes	No
Brandywine Receiver Station	MA	No	No	No	No	Possible	No	No	No	No
Brandywine Storage Annex/ DRMO	MA	No	No	No	No	Possible	No	No	No	No

[10] A link to periodically updated online maps is provided in Appendix A for the rusty patched bumble bee, rather than overlay maps because distribution survey results are continuing to be submitted, even after finalization of this *Reference Guide*. The species currently is known from IL, IN, IA, ME, MA, MN, OH, VA, and WI. Areas in MD, NC, PA, and TN supported rusty patched bumble bees relatively recently, are still being surveyed, and may include important areas for recovery. Managers of Air Force lands in any of the aforementioned states should review the online range information to determine if they are within its range, and then contact their local USFWS ES Office if they have additional questions.

[11] Adequate information currently is not available to include a map of the range of the seven Hawaiian yellow-faced bees listed under ESA on October 31, 2016. However, *Hylaeus anthracinus* and *H. longiceps* have been found recently at Ka'ena Point on Oahu (see Magnacca and King, 2013). The other listed *Hylaeus* species have been recorded from higher elevations or are not known to occur on Oahu.

Air Force Lands	State	Dakota skipper	El Segundo blue	Lesser long-nosed bat	Mitchell's satyr	Rusty patched bumble bee[10]	St. Francis' satyr	Taylor's checkerspot	Valley elderberry longhorn beetle	Yellow-faced bees (*Hylaeus anthracinus, H. longiceps*)[11]
Cape Cod AS	MA	No	No	No	No	Possible	No	No	No	No
Columbus AFB	MS	No	No	No	Near[12]	No	No	No	No	No
Davidsonville Transmitter Site	MD	No	No	No	No	Possible	No	No	No	No
Davis-Monthan AFB	AZ	No	No	Yes	No	No	No	No	No	No
Fort Fisher Recreation Area	NC	No	No	No	No	Possible	No	No	No	No
Fourth Cliff Recreation Annex	MA	No	No	No	No	Possible	No	No	No	No
Grissom AFB	IN	No	No	No	No	Possible	No	No	No	No
Hanscom AFB	MA	No	No	No	No	Possible	No	No	No	No
Ipswich Antenna Farm Annex	MA	No	No	No	No	Possible	No	No	No	No
Joint Base Andrews	MD	No	No	No	No	Possible	No	No	No	No
Joint Base - Ft Eustis	VA	No	No	No	No	Possible	No	No	No	No

[12] The range of Mitchell's satyr is expanding and it could be found on Columbus AFB.

Air Force Lands	State	Dakota skipper	El Segundo blue	Lesser long-nosed bat	Mitchell's satyr	Rusty patched bumble bee[10]	St. Francis' satyr	Taylor's checkerspot	Valley elderberry longhorn beetle	Yellow-faced bees (*Hylaeus anthracinus, H. longiceps*)[11]
Joint Base - Langley AFB	VA	No	No	No	No	Possible	No	No	No	No
Joint Base - Lewis	WA	No	No	No	No	No	No	Yes	No	No
Joint Base - McChord	WA	No	No	No	No	No	No	Yes	No	No
Ka'ena Point STS	HI	No	No	No	No	No	No	No	No	Yes
Los Angeles AFB	CA	No	Yes	No	No	No	No	No	No	No
Luke AFB	AZ	No	No	Yes	No	No	No	No	No	No
McClellen AFB	CA	No	No	No	No	No	No	No	Yes	No
Minot AFB	ND	Yes	No	No	No	No	No	No	No	No
Pope AFB	NC	No	No	No	No	Possible	Yes	No	No	No
Sagamore Hill Elect Research	MA	No	No	No	No	Possible	No	No	No	No
Seymour Johnson AFB	NC	No	No	No	No	Possible	No	No	No	No
Scott AFB	IL	No	No	No	No	Possible	No	No	No	No
Sudbury Elec Research Annex	MA	No	No	No	No	Possible	No	No	No	No
Travis AFB	CA	No	No	No	No	No	No	No	Yes	No
Vandenberg AFB	CA	No	Yes	No	No	No	No	No	No	No

Air Force Lands	State	Dakota skipper	El Segundo blue	Lesser long-nosed bat	Mitchell's satyr	Rusty patched bumble bee[10]	St. Francis' satyr	Taylor's checkerspot	Valley elderberry longhorn beetle	Yellow-faced bees (*Hylaeus anthracinus, H. longiceps*)[11]
Wright-Patterson AFB	OH	No	No	No	No	Possible	No	No	No	No

SECTION 1. C. PROPOSED, CANDIDATE AND PETITIONED SPECIES UNDER ESA

HIGHLIGHTS

- Proactive conservation of proposed, candidate and petitioned species is recommended to avoid listing of these species under ESA in the future
- Review Table 4 to determine if any pollinator species that are proposed or candidates for listing under ESA are found in your state
- Review Table 5 to determine if USFWS has been petitioned to list additional pollinators in your state
- Periodically check USFWS website with Federal Register Notices for determinations on petitioned species
- Seek additional information on proposed or candidate species from the ECOS website, state fish and wildlife agencies, and the local USFWS ES office
- Coordinate with USFWS species lead on actions that can be taken to conserve proposed and candidate species found on Air Force lands
- Explore whether a Candidate Conservation Agreement (CCA) is appropriate
- Voluntary conservation actions for at-risk species conducted prior to listing may be eligible for credit that can be used to offset adverse effects of actions under a post-listing Section 7 consultation

USEFUL WEBSITES

- Species information (ECOS): http://ecos.fws.gov/ecp/
- USFWS ES office locations: https://www.fws.gov/ecological-services/map/index.html
- USFWS website with Federal Register Notices: https://www.fws.gov/policy/frsystem/default.cfm

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 8: A basic reconnaissance survey to determine presence of candidate species is required, and development of an ecosystem management strategy to protect and conserve candidate species is encouraged on Air Force lands

Four pollinator species are currently candidates for listing under ESA, but have no formal listing decision as of October 26, 2017 (Table 4). Information on these species may be available on the ECOS website or through state fish and wildlife agencies. No pollinator species are proposed for listing as of October 26, 2017. Proactive conservation is recommended to avoid listing of these species under ESA in the future. Conservation actions aimed at proposed and candidate species could also benefit other pollinator species that rely on the same habitat components.

As of October 26, 2017, USFWS has determined there is substantial information that 12 pollinator species that it has been petitioned to list may warrant listing (Table 5). However, a listing determination has not yet been made for these species. Additional information on these petitioned species may be available on the ECOS website, or through state fish and wildlife agencies. USFWS will publish the decision in the *Federal Register* once a listing determination is made. USFWS maintains a searchable website with *Federal Register* notices. If a petitioned species is known to occur on Air Force lands, the website can be periodically checked for a determination.[13]

Contact the local USFWS ES office for assistance in determining whether Air Force properties are within the known range of proposed or candidate species. If it is determined that Air Force lands are within the known range of candidate species, the USFWS ES office can provide advice on the need, appropriate times, and methods for discovery or habitat assessment surveys. As stated in the previous section, AFI 32-7064, Chapter 8 requires a basic reconnaissance survey to determine the presence of any federal candidate species.

Once it has been determined that a proposed or candidate pollinator species is present on Air Force lands, coordinate with the USFWS species lead (obtain the name of the species lead from the local USFWS ES Office) on actions that can be taken to conserve the species, which may preclude the need for USFWS to list the species. Conservation actions may involve conducting population surveys, assessing habitat conditions, identifying priority areas for conservation, implementing methods to conserve the species, reducing threats to the species, and working cooperatively with other landowners within the species range. Candidate Conservation Agreements (CCAs) with USFWS are a useful conservation tool that can be used to formalize measures to address threats, conserve, and monitor candidate species. Such agreements are considered in assessing the status of the species for listing decisions. AFI 32-7064, Chapter 8 encourages development of an ecosystem management strategy to provide for protection and conservation of candidate species when practical.

The Air Force may be able to receive credit for voluntary conservation actions taken for species prior to their listing under ESA (including proposed species, candidate species, species petitioned for listing, and other at-risk species) that: (1) implement a species conservation strategy developed or adopted by one or more states and (2) are part of a State program that is set up per USFWS's Voluntary Prelisting Conservation Policy and has been reviewed by USFWS. Credits generated through State-led programs can be used either by the person or organization who undertook such actions or by a third party to whom the credit has been transferred or sold. These credits will mitigate or serve as a compensatory measure for the negative effects of another action undertaken after listing. For actions to be considered for credit they must be voluntary (not required by federal, state or local regulation) and not used to satisfy other requirements for

[13] USFWS recently published National Listing Workplan (Workplan) for addressing ESA listing and critical habitat decisions over the next seven years that will be updated periodically. The Workplan identifies the fiscal year in which determinations are expected on petitioned species and can be found at: https://www.fws.gov/endangered/improving_esa/listing_workplan.html

mitigation or compensation. Such credits can be used by federal agencies to offset adverse effects of actions under a post-listing Section 7 consultation (USFWS, 2017a).

Hermes copper (*Lycaena hermes*), a candidate for listing, found only in California (photo: Michael Klein, Sr./USFWS CC BY 2.0)

Table 4: Pollinator species designated as candidate species under ESA

Species Group	Species	States/Territories with known occurrences	Lead USFWS office
Butterflies	Hermes copper (*Lycaena hermes*)	CA	Carlsbad Field Office
Butterflies	Island large marble butterfly (*Euchloe ausonides insulanus*)	WA	Washington Fish and Wildlife Office
Butterflies	Puerto Rico harlequin butterfly (*Atlantea tulita*)	PR, VI	Caribbean Ecological Services Field Office
Butterflies	Rattlesnake-master borer (*Papaipema eryngii*)	AR, IL, KY, NC, OK	Rock Island Ecological Services Field Office

Caterpillar of the monarch butterfly (*Danaus plexippus plexippus*), a species USFWS has been petitioned to list (photo: Rick Hansen/USFWS)

Table 5: Pollinator species that USFWS has been petitioned to list under ESA

Species Group	Species	States with known occurrences
Bees	Blue calamintha bee (*Osmia calaminthae*)	FL
Bees	Franklin's bumble bee (*Bombus franklini*)	CA, OR
Bees	Yellow banded bumble bee (*Bombus terricola*)	CT, IL, KY, MA, MD, ME, MI, MN, MT, NC, ND, NH, NY, OH, PA, RI, SD, TN, VA, VT, WI, WV
Bees	Western bumble bee (*Bombus occidentalis*)	AK, AZ, CA, CO, ID, MN, MT, ND, NE, NM, NV, OR, SD, WA, WY
Fly	San Joaquin Valley giant flower-loving fly (*Rhaphiomidas trochilus*)	CA
Butterflies	Ferris's copper (*Lycaena ferrisi*)	AZ
Butterflies	Great Basin silverspot (*Speyeria nokomis nokomis*)	CO, UT
Butterflies	Monarch butterfly (*Danaus plexippus plexippus*)	AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, MT, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OK, OR, PA, RI, SC, SD, TN, TX, UT, VA, VT, WA, WI, WV, WY
Butterflies	Regal fritillary (*Speyeria idalia*)	AR, CO, CT, DE, IA, IL, IN, KS, MA, MD, ME, MI, MN, MO, MT, NC, ND, NE, NH, NJ, NY, OH, OK, PA, SD, VA, VT, WI, WV
Butterflies	Spring Mountains dark blue butterfly (*Euphilotes ancilla cryptica*)	NV
Butterflies	Spring Mountains dark blue butterfly (*Euphilotes ancilla purpura*)	NV
Moth	Sand-verbena moth (*Copablepharon fuscum*)	WA

SECTION 1. D. POLLINATORS DESIGNATED AS BIRDS OF CONSERVATION CONCERN

1. D. 1. Regulatory and policy protections – birds

HIGHLIGHTS

- Pollinators that are migratory birds are protected from "take"
- Some bird pollinators are identified as high priority for conservation by their designation as BCCs
- There is an MOU developed in accordance with Executive Order 13186 encouraging conservation of migratory birds and incorporation of bird management objectives in INRMPs
- Include measures to avoid "take" in INRMPs
- 50CRF21.15 authorizes take of migratory birds only for military readiness activities when the Armed Forces confers and cooperates with USFWS to develop and implement conservation measures to minimize or mitigate significant adverse effects

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 7.4: Calls for incorporating migratory bird conservation into the installation INRMP as practicable

Migratory birds that are pollinators (e.g., Rufous Hummingbird, *Selasphorus rufus*) are afforded more protection than many other pollinators because they are protected by MBTA. MBTA protects migratory birds (including their eggs, nests, or any parts), from take without a permit. Take is defined under MBTA as to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect. In addition eight hummingbirds and nine honeycreepers, that are pollinators, are designated as BCCs in at least part of their range under FWCA. BCCs are non-listed birds that have been identified as the highest priority for conservation action. A list of pollinator species designated BCCs in at least part of their range is provided in Table 6.

Most DoD activities, such as natural resource management, are considered within the MOU between DoD and USFWS developed in accordance with Executive Order 13186, *Responsibilities of Federal Agencies to Protect Migratory Birds*. This MOU encourages incorporation of migratory bird management objectives into INRMPs; evaluation of likely effects of planned activities on migratory birds; protection, enhancement and restoration of unique habitats; and collaboration to promote migratory bird research and conservation. AFI 32-7064, Chapter 7.4, which calls for incorporating migratory bird conservation into the installation INRMP as practicable, is consistent with the MOU.

Measures to avoid take of migratory birds usually are identified in INRMPs. Incidental take permits under MBTA are very rare. However, there is a provision in 50 CFR 21.15 authorizing take for *military readiness* activities provided the Armed Forces confers and cooperates with USFWS to develop and implement appropriate conservation measures to minimize or mitigate any significant adverse effects of the activities.

Rufous Hummingbird (*Selasphorus rufus*), a BCC (photo: Chelsea McKinney/USFWS)

Table 6: Pollinator species designated BCCs under FWCA

Species Group	Species	States with known occurrences
Honeycreepers	'Akeke'e or Kaua'i 'Akepa [14] (*Loxops caeruleirostris*)	HI
Honeycreepers	'Akikiki[15] (*Oreomystis bairdi*)	HI
Honeycreepers	'Anianiau (*Magumma parva*)	HI
Honeycreepers	'Apapane (*Himatione sanguinea*)	HI
Honeycreepers	Hawai'i 'Amakihi (*Chlorodrepanis virens*)	HI
Honeycreepers	'I'iwi[16] (*Drepanis coccinea*)	HI
Honeycreepers	Kaua'i 'Amakihi (*Chlorodrepanis stejnegeri*)	HI
Honeycreepers	Maui 'Alauahio (*Paroreomyza montana*)	HI
Honeycreepers	O'ahu 'Amakihi (*Chlorodrepanis flava*)	HI
Hummingbirds	Allen's Hummingbird (*Selasphorus sasin*)	AZ, CA, OR
Hummingbirds	Antillean Mango (*Anthracothorax dominicus*)	PR
Hummingbirds	Blue-throated Hummingbird (*Lampornis clemenciae*)	AZ, TX
Hummingbirds	Buff-bellied Hummingbird (*Amazilia yucatanensis*)	AL, FL, LA, MS, TX
Hummingbirds	Calliope Hummingbird (*Selasphorus calliope*)	AZ, CA, CO, ID, MN, MT, NV, OR, UT, WA, WY
Hummingbirds	Costa's Hummingbird (*Calypte costae*)	AZ, CA, NV
Hummingbirds	Lucifer Hummingbird (*Calothorax lucifer*)	AZ, NM, TX
Hummingbirds	Rufous Hummingbird (*Selasphorus rufus)*	AK, AZ, CA, CO, MN, MT, NV, ID, OR, TX, UT, WA, WY

[14] Also listed as endangered under ESA.

[15] Also listed as endangered under ESA.

[16] Also listed as threatened under ESA. Listed under its former scientific name, *Vestiaria coccinea,* in some locations.

1. D. 2. Process for addressing pollinators that are BCCs

HIGHLIGHTS

- Use Table 7 to determine which Air Force lands are found within the range of a pollinator designated as a BCC.
- Refer to Appendix A, Section 2 (Appendix A-2) for a species range map
- For Air Force lands within the range of a pollinator that is a BBC where a discovery or reconnaissance survey has not been conducted on Air Force lands:
    - use the species profile in Appendix A-2 to become familiar with the species
    - contact USFWS Headquarters Migratory Birds Program (USFWS-HQ-MB) regarding the need and techniques for discovery surveys and habitat assessments
- If a pollinator that is a BCC is found on Air Force lands, then:
    - work with USFWS HQ-MB, and others to identify priority areas on Air Force lands for conservation actions
    - explore partnerships that would be beneficial for species conservation, and reduce the burden on Air Force lands
- Include conservation actions in the installation INRMP

HELPFUL WEBSITE AND TELEPHONE CONTACT

- Species information (ECOS): http://ecos.fws.gov/ecp/
- USFWS-HQ-MB: 703-358-1714

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 7.4: Migratory bird conservation should be incorporated into the installation INRMP, as practicable

USFWS determined which Air Force lands shown in Figures 1 and 2 are located within the range of pollinator species designated as BCCs in at least part of their range as of January 10, 2017. Table 7 provides a list of these Air Force lands. Inclusion on this list does not mean that the species presence has been confirmed on the Air Force lands, only that it is possible. If species ranges expand, contract or shift there may be changes in which Air Force lands are located within their range. BCCs that are pollinators possible on Air Force lands may change when the list of BCCs is updated.

For the bird species listed in Table 7, a map of the species range within the U.S. and a profile with basic information on the biology, habitat and threats is provided in Appendix A, Section 2 (Appendix A-2).

If Air Force lands are within the range of these birds, but surveys have not been conducted in appropriate habitats, then review the maps and species profiles in Appendix A-2 to become more familiar with the species. Additional species information and references may be found in the

ECOS. Next, contact USFWS Headquarters Migratory Birds Program (USFWS-HQ-MB; telephone number 703-358-1714) for advice on the need, appropriate times, and methods for discovery surveys.

Once it has been determined that a BCC pollinator species is present on Air Force lands, coordinate with USFWS-HQ-MB on the need and methods for assessing habitat conditions. This information can be used in cooperation with USFWS, state fish and wildlife agencies, and other landowners who have habitat for the species to identify priority areas on Air Force lands for conservation. Conservation can include taking action to improve habitat quality or reduce other threats. Suggested conservation measures for all hummingbirds are included in Appendix A-2. Conservation actions should be incorporated into INRMPs and implemented as funding is available.

Costa's Hummingbird (*Calypte costae*), a BCC (photo: Alan Schmierer/CC0 1.0)

Table 7: Air Force lands within the range of BCCs that are pollinators[17]

AF lands	State	Allen's	Blue-throated	Buff-bellied	Calliope	Costa's	Lucifer	Rufous
Barry Goldwater Range	AZ	Yes	No	No	Yes	Yes	No	Yes
Beale AFB	CA	No	No	No	Yes	No	No	Yes
Buckley AFB	CO	No	No	No	No	No	No	Yes
Cannon AFB	NM	No	No	No	No	No	No	Yes
Canyon Lake RA	TX	No	No	No	No	No	No	Yes
Carter Creek	UT	No	No	No	Yes	No	No	Yes
Creech	NV	No	No	No	Yes	Yes	No	Yes
Davis-Monthan AFB	AZ	Yes	Yes	No	Yes	Yes	Yes	Yes
Dyess AFB	TX	No	No	No	No	No	No	Yes
Edwards AFB	CA	Yes	No	No	Yes	Yes	No	Yes
Elgin AFB	FL	No	No	Yes	No	No	No	No
Fairchild AFB	WA	No	No	No	Yes	No	No	Yes
Farish Memorial Recreational Annex	CO	No	No	No	No	No	No	Yes
Fort Tuthill	AZ	No	No	No	Yes	Yes	No	Yes
Francis E. Warren	WY	No	No	No	No	No	No	Yes
Goodfellow AFB	TX	No	No	No	No	No	No	Yes
Hill AFB	UT	No	No	No	Yes	No	No	Yes
Holloman AFB	NM	No	No	No	No	No	No	Yes
Hurlburt Field	FL	No	No	Yes	No	No	No	No
JB-Elmsdorf	AK	No	No	No	No	No	No	Yes
JB-Lewis	WA	No	No	No	No	No	No	Yes
JB-McChord	WA	No	No	No	No	No	No	Yes
JB-Richardson	AK	No	No	No	No	No	No	Yes
JBSA-Camp Bullis	TX	No	No	No	No	No	No	Yes
JBSA-Fort Sam Houston	TX	No	No	Yes	No	No	No	Yes

[17] All birds in table are hummingbirds. Mtn = Mountain; RA = Recreation Area

AF lands	State	Allen's	Blue-throated	Buff-bellied	Calliope	Costa's	Lucifer	Rufous
JBSA-Lackland	TX	No	No	No	No	No	No	Yes
JBSA-Randolph	TX	No	No	Yes	No	No	No	Yes
Keesler AFB	MS	No	No	Yes	No	No	No	Yes
Kirtland AFB	NM	No	No	No	Yes	No	No	Yes
Laughlin AFB	TX	No	No	No	No	No	No	Yes
Los Angeles AFB	CA	Yes	No	No	Yes	Yes	No	Yes
Luke AFB	AZ	No	No	No	Yes	Yes	No	Yes
Malmstrom	MT	No	No	No	No	No	No	Yes
March AFB	CA	Yes	No	No	Yes	Yes	No	Yes
McClellen AFB	CA	Yes	No	No	No	Yes	No	Yes
Melrose AFB	NM	No	No	No	No	No	No	Yes
Mountain Home AFB	ID	No	No	No	Yes	No	No	Yes
Mtn Home Strike Dam Marina	ID	No	No	No	Yes	No	No	Yes
Nellis AFB	NV	No	No	No	Yes	Yes	No	Yes
Nellis AFR	NV	No	No	No	Yes	Yes	No	Yes
Oscura Bombing Gunnery Range	NM	No	No	No	No	No	No	Yes
Peterson AFB	CO	No	No	No	No	No	No	Yes
Saylor Creek Bombing Range	ID	No	No	No	Yes	No	No	Yes
Schriever AFB	CO	No	No	No	No	No	No	Yes
Seguin Auxiliary Air Field	TX	No	No	Yes	No	No	No	Yes
Silver Mountain RRA	UT	No	No	No	Yes	No	No	Yes
Travis AFB	CA	Yes	No	No	No	Yes	No	Yes
Tyndall AFB	FL	No	No	Yes	No	No	No	No
US Air Force Academy	CO	No	No	No	No	No	No	Yes
Utah Test & Training Range	UT	No	No	No	Yes	No	No	Yes
Vandenberg AFB	CA	Yes	No	No	Yes	Yes	No	Yes

SECTION 1. E. MONARCH BUTTERFLIES

HIGHLIGHTS

- The monarch butterfly is found in a variety of habitats across much of the continental U.S.
- Monarch populations have been declining across North America
- There are three priority geographic areas for monarch conservation: spring breeding habitat in Texas and Oklahoma, summer breeding habitat in the Midwest "Corn Belt," and key areas for the western population
- USFWS has been petitioned to list the monarch and anticipates a finding by June 30, 2019
- Recommended conservation actions:
    - Assess monarch habitat conditions to determine priority areas for conservation on Air Force lands
    - Maintain open sunny areas and increase available native milkweed and other native flowering plants in monarch breeding areas
    - Increase native flowering plants along migration routes
    - Eliminate or reduce the use of pesticides in areas that support monarchs
    - Eliminate invasive plants and nonnative tropical milkweed (*Asclepias curassavica*)
    - Limit disturbance of overwintering areas in California
    - Adjust management activities so as not to interfere with breeding
- Incorporate monarch conservation activities into INRMPs
- Explore whether a CCA or actions under USFWS's Voluntary Prelisting Conservation Policy would be beneficial

HELPFUL WEBSITES

- USFWS ES office locations: https://www.fws.gov/ecological-services/map/index.html
- USFWS monarch information page: https://www.fws.gov/savethemonarch/

North American monarch butterflies (*Danaus plexippus plexippus*) are a wide-ranging, charismatic insect species, well known for their spectacular long-distance migrations. The North American geographic range of the monarch butterfly includes areas in Canada, the U.S., and Mexico. The species occurs throughout a wide variety of natural and human-dominated landscapes, wherever its host plant (milkweed, primarily *Asclepias* spp.) is present, or suitable tree groves are present for overwintering. Most Air Force lands in the continental U.S. are within the range of monarch butterflies. At least one base, Vandenberg, is known to support overwintering monarchs. Maps of the range of the monarch butterfly are provided in Appendix A, Section 3 (Appendix A-3).

Monarchs in continental North America are generally divided into three populations. The first two populations, the eastern and western, generally migrate to separate overwintering grounds in

Mexico and along the coast of California, respectively. Some monarchs overwinter at inland sites in the western U.S. as well. The third population is the non-migratory southern Florida population, in which monarchs are present year-round throughout southern Florida. The populations of monarch butterflies have declined significantly since the mid-1990s. Drivers of the population declines are believed to be habitat loss on breeding and overwintering grounds, pathogens and parasites, pesticides and climate change (Jepsen, et al., 2015; Knight and Brower 2009; Rendón -Salinas, et al., 2015; Semmens, et al., 2016; Solensky, 2004; Taylor, 2016).

USFWS has established a biological objective for the eastern monarch population of 225 million butterflies occupying six hectares (approximately 15 acres) of overwintering habitat in Mexico by 2020 to address these declines. The objective is documented in the *National Strategy to Promote the Health of Honey Bees and other Pollinators* (*National Pollinator Strategy*) (Pollinator Health Task Force, 2015). Reaching this target is intended to increase the viability of the species. There is not currently a population target in the west. USFWS and partners are working on the most appropriate way to set biological targets for western monarchs. The U.S. monarch conservation strategy focuses on four priority geographic areas: spring breeding habitat in Texas and Oklahoma, summer breeding habitat in the Midwest "Corn Belt," breeding habitat in California's Central Valley for the western population, and key overwintering sites along coastal California.

USFWS was petitioned to list the North American monarch butterfly under ESA and determined that there is substantial information that may warrant listing. USFWS is currently assessing the status of the species. Based on a recent settlement agreement, USFWS anticipates completing the 12-month finding by June 30, 2019. Proactive conservation now can be beneficial to the Air Force because ongoing conservation is considered in determining whether listing under ESA is warranted.

Managers of Air Force lands within the range of the monarch butterfly should consider coordinating with the local USFWS field office, state fish and wildlife agencies and other partners to determine priority areas for monarch conservation and for assistance in developing and implementing site-specific management recommendations and plans. They should also consider whether a CCA or actions under the USFWS Voluntary Prelisting Conservation Policy (both described in Section 1.C) would be beneficial to the Air Force. Any conservation actions should be documented in the installation INRMP.

Conservation recommendations for the eastern and western monarch butterfly populations include:

1. Assessing monarch habitat conditions to determine priority areas for conservation on Air Force lands in consultation with the local USFWS field office, state fish and wildlife agencies and other partners.
2. Increasing native milkweed and other native flowering plants in monarch breeding areas.
3. Increasing native flowering plants along migration routes during the time of migration.
4. Maintaining open, sunny areas where native flowering plants thrive.
5. Eliminating or reducing the use of pesticides in areas with monarchs.
6. Eliminating invasive plants and nonnative tropical milkweed (*A. curassavica*), which is believed to promote the spread of disease (e.g., *Ophryocystis elektroscirrha*) in migratory monarchs.

7. Limiting disturbance of overwintering areas in California.
8. Adjusting management activities (timing of mowing, amount of grazing, timing and size of prescribed fire units) so not to interfere with breeding.

These recommendations discussed in more detail in the species profile in Appendix A-3.

Monarch butterfly (photo: Brett Billings/USFWS)

SECTION 2: CONSERVING AND ENHANCING POLLINATOR HABITAT

This section provides information needed to improve management of habitat for pollinators. Section 2.A provides information about the food and habitat needs of the major groups of pollinators. Section 2B provides information on implementing land management practices to benefit pollinators. The ecoregion concept is introduced in Section 2.B.1 and maps are provided showing the ecoregions in which Air Force lands are located. This information can be used along with the native plant lists by ecoregion provided in Appendix B, Section 1 (Appendix B-1) to select area specific plants for habitat restoration and landscaping. Information about preparing an area for planting and planting techniques is provided in Appendix B, Section 2 (Appendix B-2).

Habitat conservation and enhancement can benefit large numbers of pollinator species (bees, butterflies, and some moths, flies, beetles, birds, and bats) across America whose status is not well known. Actions that enhance habitat for pollinators by providing food and shelter, reducing threats (e.g., improper use of pesticides), or enhancing resiliency (e.g., connecting suitable patches of habitat) will benefit a wide variety of pollinators. Actions that benefit pollinator health can improve the entire ecosystem because of the vital role of pollinators in plant reproduction, and the many animals that are dependent on the seeds and fruits of animal-pollinated plants.

Some areas of Air Force installations are more suitable for pollinator habitat conservation due to current use and/or habitat condition. For example, conservation on unimproved (natural) areas, buffers, recreation areas, rights-of-way, golf courses, and landscaped areas may be more compatible with mission requirements than other areas. These areas should be a priority for implementing pollinator habitat improvements and using land management practices in ways beneficial to pollinators. Identifying areas for pollinator conservation and specific on-the-ground measures and projects to benefit pollinators in INRMPs is critical to conserving pollinator habitat.

This section of the *Reference Guide* contains information on the requirements for successful pollinator conservation that can be used to help determine where pollinator conservation is most compatible with mission requirements. It also contains information on how to modify land management techniques to either provide benefit or minimize harm to pollinators.

SECTION 2. A. THE BASIC NEEDS OF POLLINATORS

2. A. 1. Food for pollinators – native plants

HIGHLIGHTS

- Many pollinators use sunny, open areas or habitat edges where flowering plants are abundant
- Flowering plants need to be near pollinator nesting sites
- Pollinators feed on nectar from native plants with flowers in a variety of colors, shapes, sizes and scents, that bloom throughout the time pollinators are active
- Flowers of the same species found in clumps are preferred by specialist pollinators
- Some pollinators need a source of water
- Adult pollinators may also feed on pollen, plant sap, insects, fruits or seeds
- Immature stages of pollinators may eat different food than adults, including leaves, seeds, fruit, insects, wood, and carrion
- Specialist bees, and butterfly and moth larvae require specific plant species

HELPFUL WEBSITES

- Find butterfly and moth larval host plants at: http://www.butterfliesandmoths.org/species_search
- Generate a checklist of butterflies found in a particular county at: http://www.butterfliesandmoths.org/checklists
- Find plants used by specialist bees in the northeast and mid-Atlantic at: http://jarrodfowler.com/specialist_bees.html

One of the basic requirements for high quality pollinator habitat is a diversity of native flowering plants near where pollinators nest. Some of the smaller native bees will only forage a few hundred feet from their nests. Native flowering plants are often found in sunny, open areas or the edge of woody habitats where flowers are abundant. Native flowering plants provide nectar to pollinators. Different groups of pollinators are attracted to and able to collect nectar from flowers with different characteristics (Table 8). Healthy pollinator habitat includes flowers with a variety of colors, shapes, sizes, and scents. Large patches of the same flower species are more attractive to some pollinators than individual flowers scattered across a wide area. Pollinators that specialize on a particular flower, save energy when they can forage on flowers close to each other. Some bees specialize on collecting nectar and pollen from certain plant species. At this time, the only readily available lists of plants for specialist bees are for the Northeast and Mid-Atlantic (see Highlights box for website). Research has shown that native plants support more bees, butterflies and moths than nonnative plants (Anderson and Bailey, 2010; Burghardt, et al., 2009; Council on Environmental Quality (CEQ), 2014; Fowler and Droege, 2015; Lee-Mäder, et. al., 2013; Mader, et al, 2011; U.S. Department of Agriculture (USDA) and DOI, 2015).

Different species of pollinators are active at different times of the year. High quality pollinator habitat will have a diversity of locally native plant species that provide nectar throughout the entire time pollinators are active, including pollinators that may migrate through an area, but not breed there. Generally, in the U.S. this is from March through October, but will vary with latitude. Some pollinator species are active for much of that time (e.g., moths, hummingbirds and bumble bees), while others are active for only a few weeks (e.g., other native bee species). Trees and shrubs can be important sources of nectar early in the season in areas with few early blooming herbaceous plants (Anderson and Bailey, 2010; CEQ, 2014; Lee-Mäder, et. al., 2013; Ley, et al., no date; Mader, et al, 2011; Marks, 2005; Vaughan and Black, 2007).Nutritional requirements for all life stages of pollinators are important. The vast majority of pollinators are insects that undergo complete metamorphosis with four life stages: egg, larva, pupa, and adult (Figure 3). The adult insect is the pollinator and feeds on nectar. Adult pollinators may supplement their diet with pollen, plant sap, insects, fruits or seeds. Some require water. Some immatures (larvae) feed primarily on nectar and pollen (e.g., bees) while others feed on the leaves, seeds or flowers of specific plant species or genera (e.g., butterflies and moths); and others feed on nectar and insects (e.g., hummingbirds). Yet other pollinator young feed on wood or other insects (beetles), or carrion (some flies), and some are even parasites of other insects (e.g., some flies and beetles). Butterflies and moths are usually quite specific in what plants the larvae (caterpillars) will eat. Host plants (food plants for larvae) can be found on the *Butterflies and Moths of North America* website. A list of butterflies found in a particular county can be generated on that website (Borror, et al, 1981; Evans, 1984; Marks, 2007; Schweitzer, et al, 2011; Scott, 1986).

L to R: White lined sphinx moth **(*Hyles lineata)* on showy milkweed (*Asclepias speciosa)*** (photo: Tom Koerner/USFWS CC BY 2.0)**; Western bumble bee (*B. occidentalis*), a declining bumble bee of the west** (photo: Stephen Ausmus/ USDA, Agricultural Research Service (ARS)

Table 8: Pollinator foods[18]

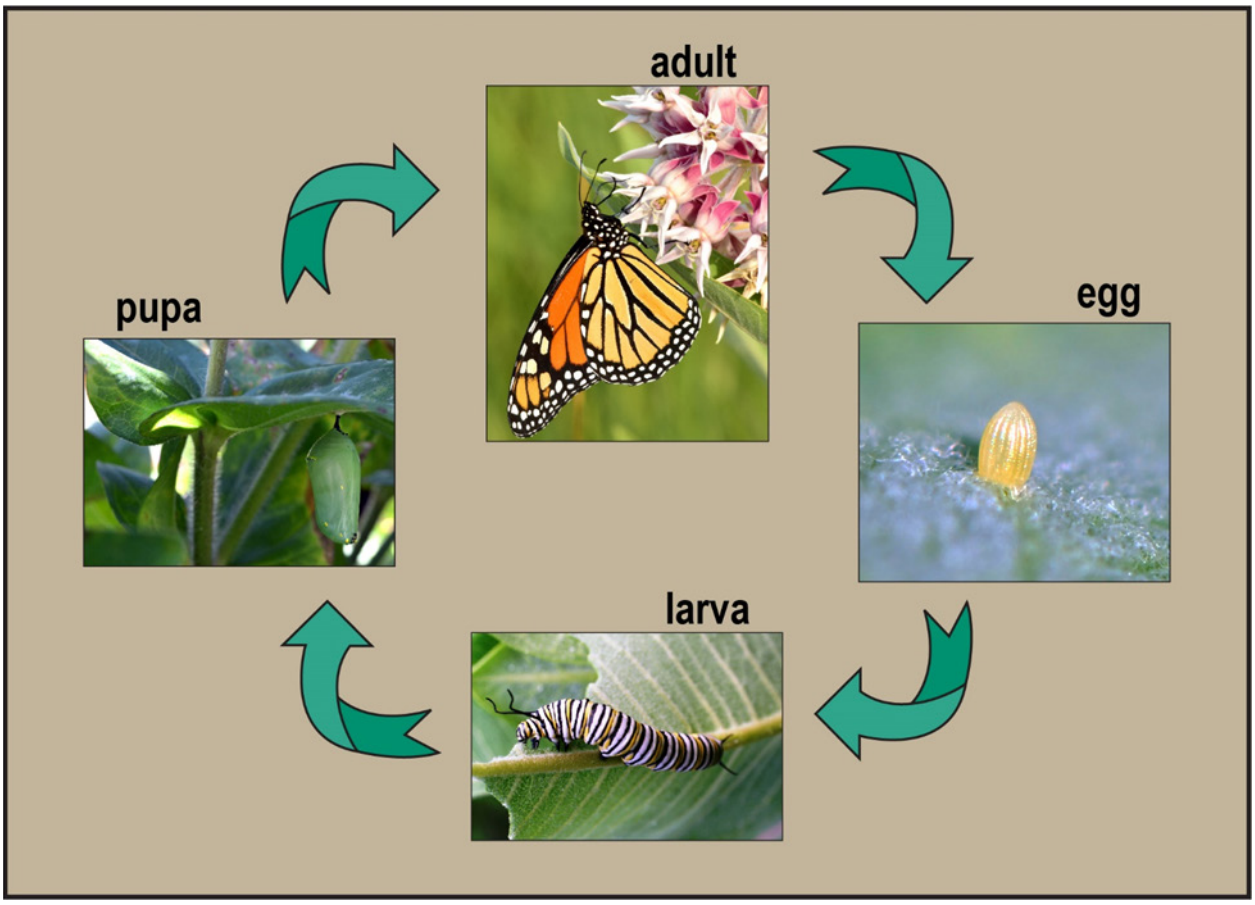
Species group	Adult food	Floral preferences	Juvenile/ Larval foods	Notes
Honeycreepers	Nectar, fruit, seeds, insects, caterpillars, spiders. 'Ohi'a trees (*Metrosideros polymorpha*) are an important food source for many	Varies – colorful, tubular flowers, but also visits yellow, green, and white flowers	Nectar and insect slurry regurgitated by both parents	Move seasonally to follow availability of nectar flowers
Hummingbirds	Nectar, insects, spiders, tree sap	Red tubular flowers, no odor	Nectar and insect slurry regurgitated by mother.	Visit same flowers in same order daily (trap-line)
Bees	Nectar, pollen	Brightly colored flowers (e.g., yellow, blue) can be showy (bell or funnel shaped, with lips, etc.) or open with many florets, sweet scent	Nectar, pollen	Use nectar guides visible in ultraviolet light
Butterflies	Nectar (a few also eat plant sap or pollen)	Varies – red and orange or no preference, flowers with large petals or with many small flowers in a flat-topped cluster	Plant parts (e.g., leaves, seed pods)	Adults need to perch while feeding; larger species tend to feed on taller plants and smaller species on shorter plants; some males obtain minerals from mud puddles

[18]Sources: Barth, 1991; Elphick, et al., 2001; Evans, 1984; Fitzgerald, 2004; Harvey, et al., 1999; Ley, et al. (no date); Mader, et al., 2011; Marks, 2005; NRC, 2007; Scott, 1986; Williamson, 2001.

Species group	Adult food	Floral preferences	Juvenile/ Larval foods	Notes
Moths	Nectar	White or pale, open at night with a strong odor; day flying hawk moths feed on flowers in a variety of colors	Leaves, and sometimes other plant parts	Some hover while feeding
Flies	Nectar, pollen	Varies - brightly colored and similar to those visited by bees, OR white with a strong odor; various shapes (funnel like or complex traps)	Insects, some are parasitic on other insects, a few are scavengers	Some hover while feeding; fly in poor, cool weather when bees do not – can be important pollinators in alpine areas and Arctic tundra
Beetles	Nectar and/or pollen, flowers, a few also feed on insects	Simple, open flowers with sweat, spicy, fruity odor	Insects, some are parasitic on other insects; a few feed on carrion and excrement	Sometimes remain in flowers overnight and may damage flowers as they feed
Bats	Nectar, pollen, fruit, insects, flower parts	Dull-colored, open at night, strong odor, bowl shaped	Nurse, then same food as adults	There are only four species of nectar feeding bats in the U.S., all in the family Phyllostomidae

Milkweed flowers provide nectar for adult Monarch butterflies and the leaves provide food for monarch larvae (photo: Tom Koerner/USFWS CC BY 2.0)

Figure 3: Insect life cycle (with complete metamorphosis)



Photos (clockwise from left): Monarch butterfly pupa (Tina Shaw/USFWS)**, adult** (Tom Koerner/CC BY 2.0)**, egg (**Joanna Gilkeson/USFWS)**, and larva** (Rick Hansen/USFWS**)**

2. A. 2. Native nesting and overwintering habitat

HIGHLIGHTS

- Trees, shrubs, snags, logs, and plants with stems with hollow or soft, spongy centers all provide nesting or overwintering habitat for some pollinators
- Open patches of well-drained, sandy or loamy soil in sunny areas provide nesting sites for many bee species
- Soil and leaf litter provide overwintering sites for many insect pollinators
- Native bunch grasses provide nesting sites for bumble bees and roosting sites for butterflies
- Other pollinator nesting sites include: caves, stone walls, and insect nests
- Some pollinators require mud for nest construction

Beyond native flowering plants for foraging, pollinators need habitat for nesting and overwintering.

Trees and shrubs are important nesting sites for hummingbirds and honeycreepers and provide protection from heavy winds for insect pollinators. Standing snags and dead trees provide nesting sites for native bees, honey bees and some bats, beetles and flies. Soil and leaf litter provide overwintering habitat for many insect pollinators. Open patches of well-drained, sandy or loamy soils that receive sun (south-facing slopes are ideal) are favored by many bee species for nesting, while stream banks with exposed soil are also used (Borror, et al., 1981; Cane, 2015; Evans, 1984; Elphick et al., 2001; Fitzgerald, 2004; Harvey, et al., 1999; Marks, 2007; Ley, et al. (no date); Mader, et al, 2011, Moissett and Buchmann, 2010; Schweitzer, et al., 2011; Scott, 1986; Vaughan and Black, 2007).

Native bunch grasses are another component of pollinator habitat. Bumble bees sometimes nest under bunch grasses. Butterflies will use tall bunch grasses for roosting overnight (Lee-Mäder, et. al., 2013; Mader, et al, 2011, Marks, 2007; Schweitzer, et al., 2012; Scott, 1986; Vaughan and Black, 2007).

Less common habitats include caves, stone walls, abandoned rodents nests and the nests of other insects. Caves are often used by pollinating bats for roosting and nesting. Crevices in stone walls are used by some bumble bees for nesting. Some bees, flies and beetles are parasitic on other insects. A summary of nesting and overwintering sites for the major groups of pollinators is provided in Table 9 (Evans, 1984; Harvey et al., 1999; Hatfield, et al., 2012; Mader, et al., 2011; Marks, 2007; Moissett and Buchmann, 2010; Schweitzer, et al., 2012: USDA and DOI, 2015; Vaughan and Black, 2007).

Large carpenter bee (*Xylocopa spp.*) nest (photo: © Joe Engler used with permission)

Rufous Hummingbird gathering nesting material (Photo: George Gentry/USFWS)

Table 9: Pollinator nesting and overwintering requirements[19]

Species group	Nesting/Larval habitat	Overwintering habitat	Notes
Honeycreepers	Nest either on terminal branches or in cavities of trees; nests usually constructed of grass, twigs, and other plant materials.	Year-round residents, but some have seasonal movements in elevation or between Hawaiian islands.	Perch on open branches. Confined to the higher, mountainous habitats
Hummingbirds	Nest on thin branches in trees or bushes in cup-shaped nests constructed from soft materials, often held together with spider webs. Their nests are usually camouflaged with lichens and bark.	Varies. Some are year round residents; others migrate south for the winter.	Perch on open branches.
Bees	Nest in open sandy or loamy soil; standing snags and dead trees; soft wood or stems with hollow or soft, spongy centers; or abandoned rodent nests, under bunch grasses, openings in stone walls under piles of soil or grass clippings Some species line their nests with leaves, mud, or plant sap.	Overwinter in soil or wood. Bumble bees also use compost piles, leaf and needle litter and other natural debris.	None.
Butterflies	Eggs laid on/near plants and larvae develop on plants.	Leaf litter, soil, under loose bark, on plants.	Adults rest in tall grass, bushes, and trees.
Moths	Eggs laid on/near plants, and larvae develop on plants.	Leaf litter, soil, on plants	None.

[19] Sources: Borror, et al., 1981; Cane, 2015; Elphick, et al., 2001; Evans, 1984; Fitzgerald, 2004; Harvey, et al., 1999; Hatfield, et al., 2012; Mader, et al., 2011; Marks, 2005; Moissett and Buchmann, 2010; Schweitzer, et al., 2011; Schweitzer, et al., 2012; Scott, 1986; USDA and DOI, 2015; Vaughan and Black, 2007.

Species group	Nesting/Larval habitat	Overwintering habitat	Notes
Flies	Larvae develop on plants; on decaying vegetation or rotting wood; in nests of social hymenoptera; if parasitic, on/in other insects; a few are carrion feeders.	Leaf litter, soil, under loose bark, on decaying plants and wood.	Some hover or rest on or over the ground in sunny, open areas.
Beetles	Many lay eggs in crevices; larvae feed on insects, are parasitic on other insects, or wood-borers.	Leaf litter, soil, under loose bark, on decaying plants and wood, under rocks and logs.	Some adults will rest under bark, in trees or on logs.
Bats	Caves, abandoned mines, buildings, culverts, hollow trees.	Most overwinter in Mexico.	None.

Mustached mud bee (*Anthophora abrupta*)
(photo: Scott Bauer/USDA, ARS)

SECTION 2.B. LAND MANAGEMENT PRACTICES

2. B. 1. Native habitat restoration, landscaping and maintenance

HIGHLIGHTS

- Restore pollinator habitat by:
  - adding native flowering plants to sunny open areas
  - removing the overstory from patches within forested areas or dense shrub
- Connect habitat patches

The principles used to promote pollinator conservation are similar for restoring habitat in natural areas and landscaping. The following guidance addresses both activities together. Exceptions appropriate for one or the other are noted.

One approach for habitat restoration is to add native flowering plants to sunny open areas, such as fields, powerline rights of way and roadsides that are dominated by grasses. A second approach is to remove the overstory from patches within forested areas or dense shrub. This will allow flowering plants in the seed bank to thrive. Small habitat patches that are close to each other can support local populations of some pollinator species, as well as provide nectar for migrating pollinators. The landscaping around buildings, parking lots, and recreational areas can support pollinators if food and nesting sites are available. Connect small patches of habitat to facilitate movement of pollinators from one area to the next, increasing the effective population size and resiliency (CEQ, 2014; Mader, et al., 2011; USDA and DOI, 2015).

Open field with flowers in bloom (photo: Ryan Hagerty/USFWS)

HIGHLIGHTS

- Use Figures 4 (Lower 48 states) and 5 (Alaska and Hawaii) to find the project site's ecoregion, then use Appendix B, Section 1 (Appendix B-1) to find lists of native plants appropriate to the ecoregion
- Select plant species:
  - native to the local area (replace nonnative ornamentals)
  - appropriate for the amount of light and moisture available
  - so that several species will be flowering at all times throughout the entire pollinator active season
  - with flowers in a variety of colors, shapes, sizes, and scents to attract a diversity of pollinators
  - of different heights (herbaceous and shrubs) to provide structure and wind-breaks
  - used by specialist bees and native butterfly and moth larvae
  - with stems with hollow or soft, spongy centers (e.g., raspberry, blackberry, elderberry, boxelder, sumac, dogwood, and native roses) to provide bee nesting sites
  - that are bunch grasses to provide bumble bee nesting sites
- Some perennial plants may take two years before they flower
- Include native annual plants if:
  - blooms are desired during the first year
  - there are no flowering plants in the area
  - seed will be used to start plants

HELPFUL WEBSITES

- Forest Service (FS) ecoregion information: https://www.fs.fed.us/land/ecosysmgmt/index.html
- Ladybird Johnson Wildflower Center (plant moisture and light requirements): http://www.wildflower.org/plants/

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 12.3: Replace non-native plants with native plants; do not use invasive plants and use regionally-appropriate natives in improved/semi-improved areas to the maximum extent possible away from airfields

Select flowering plant species (including herbaceous plants, vines, shrubs and trees) that are ***native to the local area.*** Using native plants appropriate to the local area (not just native to the U.S.) is important because they will be more capable of establishing and surviving in the soils and climate of the area. Additionally, established regionally-appropriate native perennial plants

require less water than nonnative plants and do not require fertilizer because they are adapted to the local conditions (Anderson and Bailey, 2010; CEQ, 2014; USDA and DOI, 2015).

Replace nonnative ornamentals and other nonnative species with native plants. Nonnative ornamental plants may survive, but they are sometimes bred for appearance without regard to whether they provide the nectar or pollen needed by pollinators. Replacing nonnative ornamentals and other nonnative plants is consistent with AFI 32-7064, Chapter 12.3, which provides for the replacement of nonnative plants with natives and use of native plants in improved/semi-improved areas to the maximum extent possible away from airfields (CEQ, 2014; USDA and DOI, 2015).

This *Reference Guide* provides ecoregion-specific lists of native plants for pollinators as a starting point for plant selection for habitat restoration or landscaping (Appendix B-1). The *Reference Guide* uses the ecoregions of the United States mapped by Bailey in 1976, with corresponding descriptions published in 1978, and updated in 1995 (Bailey, 1995). Maps of the ecoregions showing Air Force lands are provided in Figures 4 and 5. Appendix B, Table 1 lists the ecoregion for each base. The ecoregions represent broad areas with similar associations of plants with temperature, precipitation, and soil. Bailey (1983) developed a four tier system – domains, divisions, provinces and subprovinces. This *Reference Guide* provides plants by ecoregion at the province level of Bailey's classification system for the United States. Datasets and ecoregion descriptions are available from the Forest Service (FS). The ecoregions are large areas and the plant lists are not comprehensive, therefore not all the plants on the list will be appropriate for all lands within the ecoregion. Plants that are not appropriate for a particular area or project may have close relatives that are suitable for the location and project requirements.

Consider the amount of light and moisture at the project site and select plants that will thrive in those conditions. The tables in Appendix B-1 include information on light and moisture preferences of plants. Similar information on other native plants is available on the Ladybird Johnson Wildflower Center website (Anderson and Bailey, 2010).

Select a sufficient variety of native plant species to have a minimum of 3 to 5 plant species that flower in each active season (spring, summer, and fall), for a total of 9 to 15 species. Native trees, especially those that bloom in early spring (e.g., willow, cherry, redbud, and sumac) can be beneficial to pollinators active early in the season. Trees may not be appropriate in all situations. Trees may shade too much of the site in small landscaped areas or may not be a component of the native plant community being restored (Anderson and Bailey, 2010; CEQ, 2014; Ley, et al. (no date); Marks, 2005; Mader, et al., 2011; Vaughan and Black, 2007).

Select native plants to meet the needs of a variety of pollinators. Choose plants with a variety of flower colors, shapes, sizes, and scents to attract a diversity of pollinators. Include plants of different heights (herbaceous, vines, shrubs, and, where part of the community, trees) to provide structure and a variety of habitats for nesting and roosting. Heterogeneous habitat with a diversity of plant species will also attract beneficial insects. Beneficial insects include predators (e.g., wasps and true bugs) and parasites (e.g., tachinid flies and braconid wasps) that can help control insect pests. Shrubs and trees will also provide shelter from wind (Anderson and Bailey, 2010; CEQ, 2014; Ley, et al. (no date); Marks, 2005; Mader, et al., 2011).

Specific plant genera and/or species utilized by specialist bees, butterfly larvae, and moth larvae will help support their conservation. The websites listed in the Highlights box in Section 2.A.1

provide links to plant lists, checklists of butterflies by county and lists of butterfly and moth larval host plants (Ley, et al. (no date); Mader, et al., 2011).

Native plants with stems with hollow or soft, spongy centers (e.g., raspberry, blackberry, elderberry, boxelder, sumac, dogwood, and native roses) and goldenrod (*Solidago* spp.) and coneflower (*Echinacea* spp.) stems provide nesting sites for native bees. Including native bunch grass will provide potential nesting sites for bumble bees and roosting sites for butterflies (Cane, 2015; Marks, 2005; USDA and DOI, 2015; Vaughan and Black, 2007).

To assure blooms during the first year of restoration or landscaping projects in areas with no flowering plants, include annual native flowering plants in the seed mix. Some perennial plants started from seed may take two years before they flower. Including annuals will also help prevent erosion on sites where existing vegetation was cleared (Anderson and Bailey, 2010).

Providing a variety of native wildflowers will attract pollinators (photo: George Gentry/USFWS)

Garden showing native flowers of varying colors and heights (photo: USFWS)

HIGHLIGHTS

- Plants used for restoration and landscaping can be started from see or small plants
- Collect seeds or salvage plants from areas (on base) in the vicinity of the project
- Purchase seeds or plants that are from local ecotypes
- "Certified" or "source identified" seed is best
- The websites below provide sources for native seeds and plants
- Avoid seeds and plants that have been treated with systemic insecticides

HELPFUL WEBSITES

- Native plant and seed locators:
  - Ladybird Johnson Wildflower Center: http://www.wildflower.org/suppliers/
  - Plant Native website: http://www.plantnative.org/national_nursery_dir_main.htm
- Native plant society (sponsor plant sales) locators:
  - Michigan Botanical Club: http://michbotclub.org/national-botanical-organizations
  - Ladybird Johnson Wildflower Center: http://www.wildflower.org/organizations/
- *National Seed Strategy*: https://www.blm.gov/programs/natural-resources/native-plant-communities/national-seed-strategy

Plants used for restoration and landscaping can be started from seed or small plants. Seed and plant survival is improved when the source is of local origin and already adapted to site-specific climatic and soil conditions (called "local ecotypes") (Anderson and Bailey, 2010; CEQ, 2015; Lee-Mäder, et. al., 2013; USDA and DOI, 2015).

Seeds are less expensive than plants. Seeds can be purchased or collected from other areas of the Air Force property. If collected from another area of the base, collect seed from over 50 individual plants over the extent of the local population, but no more than 20% of the viable seed from any one plant to maximize genetic diversity. If purchased, use vendors that supply local seeds or plants that are local ecotypes. Ecotypes more closely matched to the project area are better. "Certified seed" is best as it meets quality standards for purity and germination. "Source-identified seed" is even better, because the location of seed harvest is verified by the certifying agency (Anderson and Bailey, 2010).

Plants can be salvaged from other areas of the base, especially if there is construction planned that requires clearing a site. Otherwise, native plants can be purchased at some nurseries or at annual or semi-annual native plant sales often sponsored by native plant societies or other local organizations. As with seeds, plants that are local ecotypes are most likely to be successful. Nurseries should have certification of their stock source available. Locators, such as those on the

Lady Bird Johnson Wildlife Center and Plant Native websites, can be used to find native plant nurseries. This is not an endorsement of nurseries by USFWS. Listings of native plant societies can be found on websites, such as those of the Lady Bird Johnson Wildlife Center and the Michigan Botanical Club. Federal agencies are working with others to develop sources of native seeds. Information about their activities can be found in the *National Seed Strategy*. If purchasing plants, avoid plants treated with a systemic insecticide. Systemic insecticides (for example, neonicotinoids) are taken up into the plant parts and in some instances can be present throughout the life of the plant, where they will be harmful to insects. If unfamiliar with any pesticides used, contact a pest management specialist (Anderson and Bailey, 2010; CEQ, 2014; USDA and DOI, 2015).

Collecting milkweed seed (photo: Will Parson/Chesapeake Bay Program CC BY-NC 2.0)

Drying milkweed seed (photo: USFWS)

HIGHLIGHTS

- See Appendix B, Section 2.A (Appendix B-2.A) for information on standard techniques for clearing vegetation from a site
- Remove or control invasive plants. Careful planning is required if invasive plants are being used by pollinators for food or nesting (See Section 2.B.6, Invasive species control)
- Test and amend soil as needed
- See Appendix B, Section 2.B (Appendix B-2.B) for standard planting techniques
- Plant flowers of the same species in clumps at least three feet in diameter
- Do not cover the entire site in mulch over an inch deep or use landscape cloth
- Use drip irrigation or sprinklers at night if watering is needed

HELPFUL WEBSITES

- NRCS Soil Surveys: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
- Master Gardener program locator: http://ahsgardening.org/gardening-resources/master-gardeners

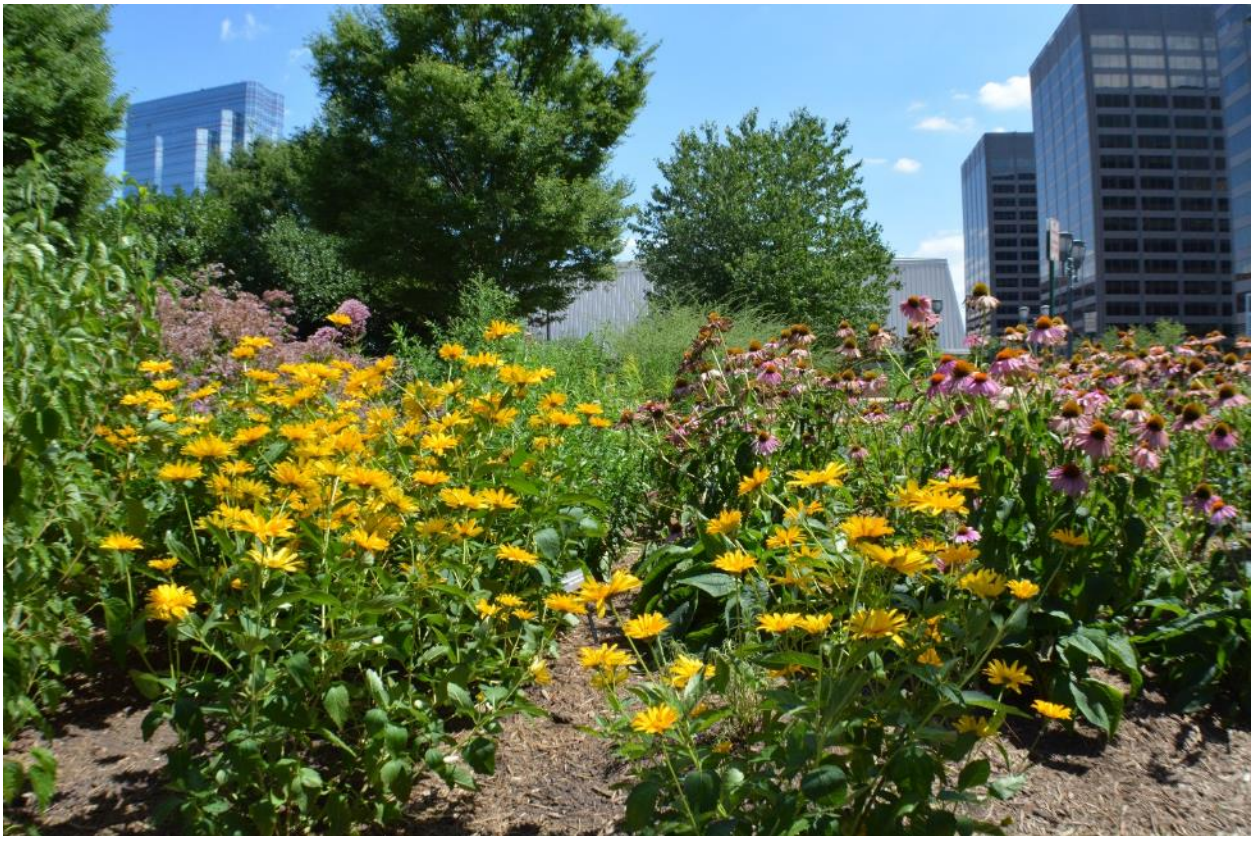
Existing vegetation may need to be cleared prior to planting. Refer to Appendix B, Section 2.A (Appendix B-2.A) for standard techniques for clearing vegetation from a site. Remove or control the spread of invasive plants as part of the site restoration. Careful planning is required when pollinators are using invasive plants for food or nesting and native plant species are not available for them to use. Section 2.B.6 provides guidance on invasive species control (Anderson and Bailey, 2010; Lee-Mäder, et. al., 2013; Mader, et al., 2011; USDA and DOI, 2015).

Understanding the soil characteristics is a critical piece for a successful restoration or landscaping project. The Natural Resources Conservation Service (NRCS) provides soil surveys and soil-plant associations for much of the United States. Complete a soil test of the area to obtain information on the level of the nutrients nitrogen (N), potassium (P), phosphorus (K), and soil pH. Soil tests may also provide information on salinity, organic content, herbicide residues, and soil-borne plant diseases. Soil tests may be obtained through the county cooperative extension service, local master gardener program, or using a kit available at a nursery. The county cooperative extension service and master gardeners typically provide a detailed soil analysis with improvement recommendations. There may be a charge for these tests. Amend the soil, as needed, before planting based on the results of soil testing. Typically a single application of balanced fertilizer at the start of the project will be all that is necessary. If using manure and/or compost be sure it is well-aged to kill all seeds within so that weeds, nonnatives or undesirable seed is not introduced. If the soil is very sandy or high in clay content, weed-free compost or other adjustments may be needed (Anderson and Bailey, 2010; Mader, et al., 2011).

See Appendix B, Section 2.B (Appendix B-2.B) for standard planting techniques. Plant individuals of the same species together to form patches at least three feet in diameter. This will increase attractiveness to pollinators. Pollinators that specialize on a particular flower save energy when they can forage on flowers close to each other (CEQ, 2014; Ley, et al. (no date); Mader, et al., 2011).

Do not disturb the soil after planting. Soil disturbance (e.g., digging, tilling, fumigating) destroys bee nests in the ground. If a rare bee species is likely, avoid tilling unless nesting sites can be identified and avoided. It is recommended that flowering plants be within a few hundred feet of native bee nest sites (Anderson and Bailey, 2010; Lee-Mäder, et. al., 2013; Mader, et al., 2011).

When landscaping, do not cover the entire site in deep mulch or use landscape cloth, as it will prevent bee nesting. If watering is necessary use drip irrigation or sprinklers at night when bees are in the nest (Cane, 2015).



Garden showing native flowers of the same species planted together (photo: Rachel Sullivan/ USFWS)

HIGHLIGHTS

- To preserve known and potential pollinator nesting and overwintering sites:
  - leave snags and dead tree trunks
  - leave open, undisturbed patches of soil
  - prevent intense grazing and excessive off-road vehicle use
  - leave open crevices (e.g., rodent holes, openings in stone walls)
  - examine dead grass piles and bunch grass for bumble bee nests before removing
- In landscaped areas:
  - wait until spring to remove dry stems with hollow or soft, spongy centers or deadhead plants
  - do not cut plants to the ground
  - if mulch is necessary, use less than an inch of pine fines, cedar mulch, or compost rather than hardwood mulch
  - never use plastic mulch
  - do not use landscape cloth
  - leave bare patches around the garden edges, between planting beds and around plants
- Artificial bee nesting sites can be made as education tools for landscaped areas; these are not recommended for natural areas because of issues with disease, use by nonnative species and attracting predators and parasites

HELPFUL WEBSITE

- Instructions for making artificial bee nesting sites: https://www.fws.gov/pollinators/PollinatorPages/YourHelp.html#bee

Sometimes all that is needed during a restoration project is to preserve known and potential pollinator nesting and overwintering sites within a few hundred feet of native flowering plants. Leave standing snags and dead tree trunks that do not pose a hazard or a problem with re-sprouting to provide nesting sites for bees and some bats, as well as habitat for beetle and fly pollinators (Evans, 1984; Ley, et al. (no date); Marks, 2005; USDA and DOI, 2015; Vaughan and Black, 2007).

Protecting bumble bee nest sites and promoting their habitat is important because at least four bumble bee species have recently declined in abundance and range (western bumble bee, *Bombus occidentalis*; American bumble bee, *B. pensylvanicus*; rusty patched bumble bee, *B. affinis*; and yellow-banded bumble bee, *B. terricola*) (Cameron, et al., 2011). Franklin's bumble bee (*B. franklini*) has not been seen since 2006, despite species-specific surveys (USFWS, 2011). Conservation of these bumble bee species should be a priority if present in the area.

Leave bare patches of soil, especially in sunny areas with well-drained sandy or loamy soils, undisturbed for native bee nesting. Open patches of soil may develop naturally at the edges of fields, gardens and roadways. Do not replant all these areas with dense vegetation, cover in deep mulch or other materials because bees will not be able to dig their nests if open soil is not available. Sites with a south or southeast aspect are considered ideal. Prevent intense grazing or excessive off-road vehicle use in important bee nesting areas (Cane, 2015; Ley, et al. (no date); Mader, et al., 2011; Vaughan and Black, 2007).

Leave small cavities within the habitat area, such as abandoned rodents nests and stone walls with openings, to provide bumble bee nest sites. Examine piles of grass or dead bunch grass for nesting bumble bees before removing (Mader, et al, 2011; Marks, 2005; Moissett and Buchmann, 2010; Vaughan and Black, 2007).

While there is no need to remove drying stems or deadhead plants in natural areas, if desired in landscaped areas, wait until spring to do so. Bees may be nesting in the stems, and seeds will either provide food for birds or contribute to the seedbank for the future. If stems with hollow or soft, spongy centers must be cut earlier, leave at least a foot of vegetation above ground. Do not cut butterfly host plants to the ground. Some butterflies lay eggs on perennial plant stems, the eggs overwinter, and if stems are removed, eggs may be removed with them (Cane, 2005; CEQ, 2014; Mader, et al., 2011; Scott, 1986; USDA and DOI, 2015; Vaughan and Black, 2007).

If mulch is necessary in landscaped areas, keep it shallow (less than one inch) and use pine fines, cedar mulch, or compost, rather than hardwood mulch. Hardwood bark has high cellulose content and as it decomposes, it robs nutrients from plants. It also makes soils more acidic, and sometimes can cause accumulation of manganese. Never use plastic mulch. Do not use landscape cloth. These prevent bee nesting. Leave some bare patches around the edge of the garden, between planting beds and/or around the base of the plants (Cane, 2015; Mader, et al., 2011).

Artificial nesting sites for bees can be made for placement in landscaped areas as an educational tool. Avoid placement in high traffic areas. Artificial nesting sites are not recommended in natural areas because of issues with disease transmission, use by nonnative species and attractiveness to predators and parasites. In natural areas, focus on protecting existing bee nesting sites and providing appropriate nesting habitat, rather than supplementing with artificial nesting sites (MacIvor and Packer, 2015).

A variety of bee species will use wood with holes drilled into it, or bundles of reeds (tied together or packed into a can, milk carton, or other container) for nesting. Different sized holes and depth holes will attract different bee species.

Use the southeast side of dead trees or logs or untreated lumber. Treated wood has toxins that may harm the bees developing within the wood.

Drill holes in wood in sizes ranging from 3/32 to 5/16 and inch.

Line the holes with paper and replace the paper annually in the spring after emergence of the bees. This will minimize transmission of disease from one year to the next. Do not use the blocks for more than two to three years because some disease organisms can get under the paper.

Disinfect wood blocks by submerging for a few minutes in a one part bleach-three part water solution annually as an additional precaution.

Provide just a few nesting cavities in each block or bundle and place the blocks or bundles 25 feet or more apart to minimize the attraction of bee predators and parasites.

Mount nesting blocks or bundles securely at least two to four feet off the ground with the openings horizontal to the ground. They should not sway in the wind. Sites that receive morning sun and are partially shaded are ideal. Some bee species in the southwest used dried mud blocks with holes drilled in them for nesting (Anderson and Bailey, 2010; Cane, 2015; Mader, et al., 2011; Vaughan and Black, 2007).

Other types of artificial bee nesting sites are less successful or more cumbersome to create. These include wooden box cavities (for bumble bee nesting) and piles of sandy (35% or more) soil at least a foot high, both of which have low occupancy rates. Methods for creating nesting sites for *Nomia melanderi* (alkali bee), a ground-nesting bee important for alfalfa pollination are more successful, but are more complex than appropriate for most situations (Cane, 2015; Evans, 1984; Mader, et al., 2011; Vaughan and Black, 2007).

Potential bee nesting sites (photo: Dolores Savignano/USFWS)

HIGHLIGHTS

- If water is provided, keep it shallow and moving (or change water every few days) to avoid problems with mosquitoes
- Rocks with shallow depressions can be used to provide water
- Treat windows with anti-reflective films, netting, or UV-reflective decals to reduce bird strikes
- Periodic management may be needed to keep pollinator habitat open and free of invasive plants
- Eliminate or minimize pesticide use in pollinator habitat areas

HELPFUL WEBSITE

- Preventing bird collisions with glass at: https://www.fws.gov/migratorybirds/pdf/management/reducingbirdcollisionswithbuildings.pdf

It may be necessary to provide water for pollinators depending on the climate and the surrounding habitat. Water sources should be very shallow, otherwise some insects and hummingbirds may drown while trying to obtain water. Uneven rocks that collect water after a rain or areas with small pebbles that are occasionally wet, can provide water for pollinators. If providing supplemental water, keep the water moving, make sure water evaporates, or change/empty the water weekly to avoid breeding mosquitoes (Centers for Disease Control and Prevention (CDC), 2016; CEQ, 2014; Ley, et al. (no date); Marks, 2005).

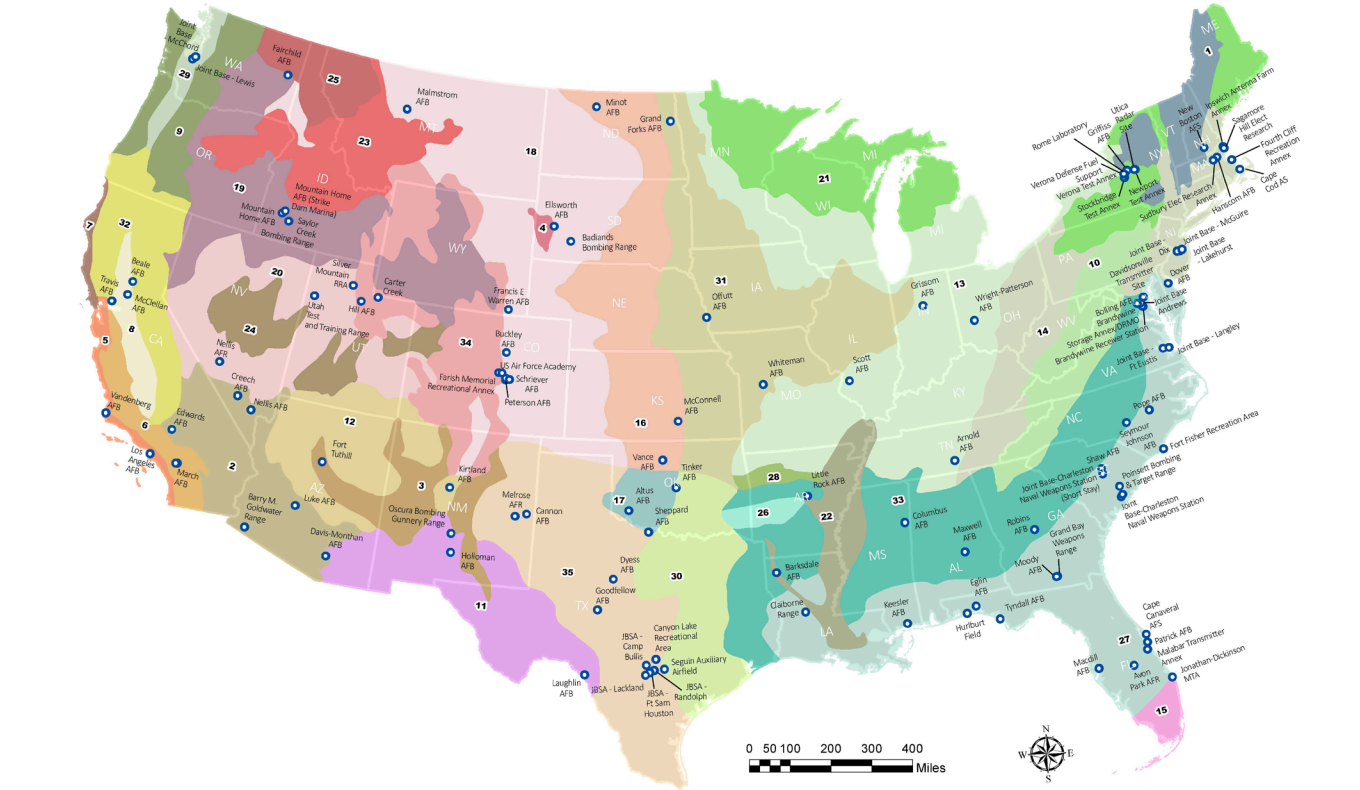
It is estimated that hundreds of millions of birds die annually in urban and rural areas as a result of collisions with both low-rise and high-rise buildings. This is often the result of birds being attracted to landscaping or natural habitat reflected in building windows. To reduce the likelihood of birds striking windows there are simple steps building occupants can take. Screening or netting on the outside of windows is effective. Keeping window blinds partially open during the day may provide enough of a deterrent. Creating a pattern on the window in a color that contrasts well with the window background helps reduce collisions. Current recommendations are for vertical stripes that are at least one-quarter inch wide with a maximum spacing of four inches, or horizontal stripes that are at least one-quarter inch wide with a maximum spacing of two inches. Closer spacing is recommended for hummingbirds. Applying the pattern on the outer glass is most effective. Place hummingbird feeders three feet or less from windows; the closer to the window the better (USFWS, 2016).

Since many pollinators thrive in open, sunny areas, periodic management may be necessary to keep the area open. Mowing, bush hogging, using prescribed fires, selectively removing trees, or other measures can be used to keep the area open (Sections 2.B.2, Mowing and brush hogging and 2.B.4, Prescribed fires). Heterogeneity is key and successional setback is important. Periodically scout for and remove invasive species to prevent them from colonizing and getting a

foothold in the area. If invasive plants cover large areas, see Section 2.B.6. Finally, eliminate or minimize the amount of pesticides used in the area (see Section 3 for specific recommendations; CEQ, 2014; Ley, et al. (no date); Mader, et al., 2011; USDA and DOI, 2015).

Rocks used to collect water intermittently (photo: Rachel Sullivan/USFWS)

Figure 4: Ecoregions of the United States: Lower 48



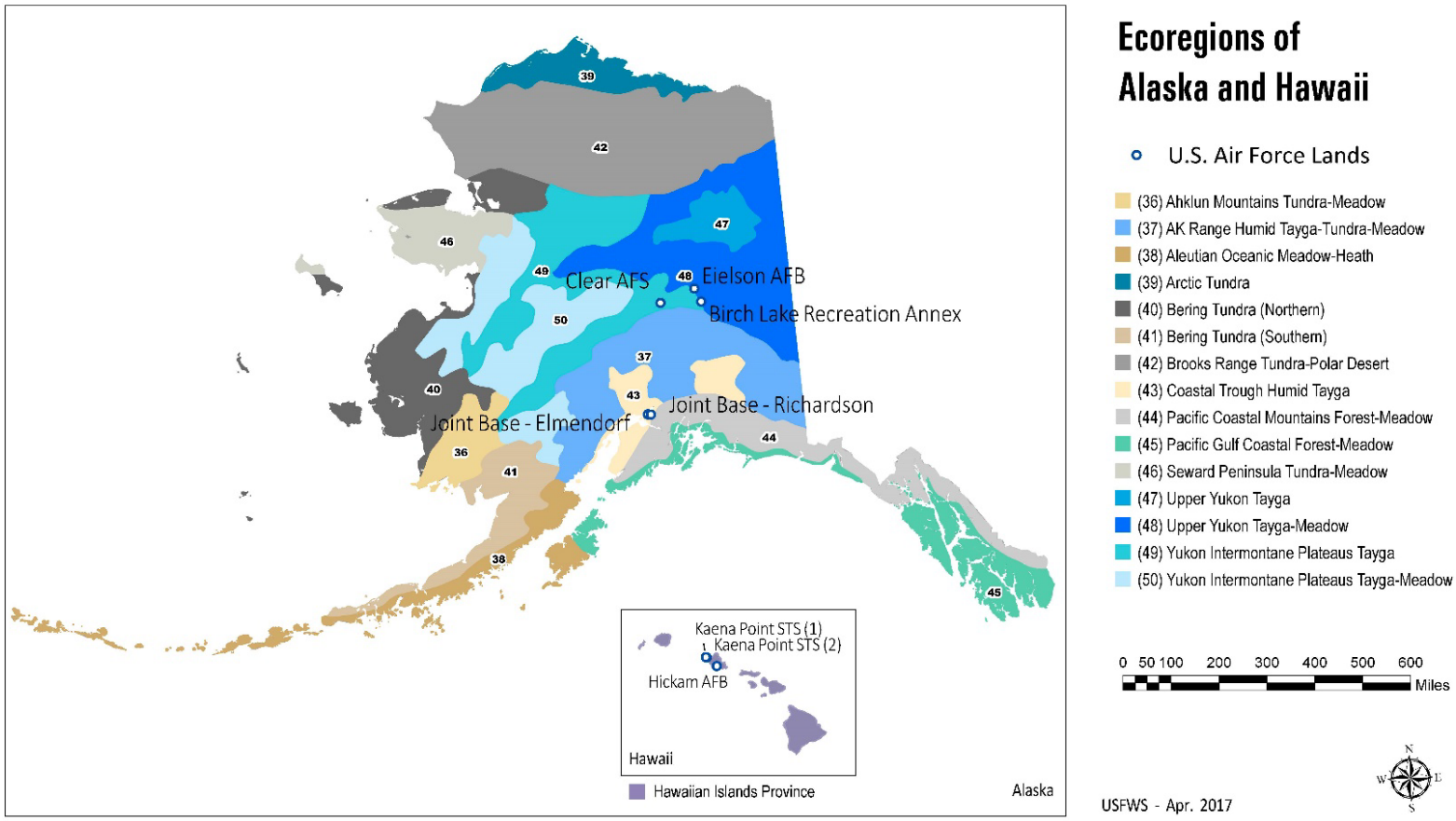
Ecoregions of the Lower 48 U.S. States

- U.S. Air Force Lands

USFWS - Apr. 2017

(1) Adirondack-New England Mixed Forest-Coniferous Forest-Alpine Meadow
(2) American Semi-Desert and Desert
(3) AZ-NM Mtns Semi-Desert-Open Woodland-Coniferous Forest-Alpine Meadow
(4) Black Hills Coniferous Forest
(5) California Coastal Chapparral Forest and Shrub
(6) California Coastal Range Open Woodland-Shrub-Coniferous Forest-Meadow
(7) California Coastal Steppe-Mixed Forest-Redwood Forest
(8) California Dry Steppe
(9) Cascade Mixed Forest-Coniferous Forest-Alpine Meadow
(10) Central Appalachian Broadleaf Forest-Coniferous Forest-Meadow
(11) Chihuahuan Semi-Desert
(12) Colorado Plateau Semi-Desert Province
(13) Eastern Broadleaf Forest (Continental)
(14) Eastern Broadleaf Forest (Oceanic)
(15) Everglades
(16) Great Plains Steppe
(17) Great Plains Steppe and Shrub
(18) Great Plains-Palouse Dry Steppe
(19) Intermountain Semi-Desert
(20) Intermountain Semi-Desert and Desert
(21) Laurentian Mixed Forest
(22) Lower Mississippi Riverine Forest
(23) Middle Rocky Mtn Steppe-Coniferous Forest-Alpine Meadow
(24) NV-UT Mtns-Semi-Desert-Coniferous Forest-Alpine Meadow
(25) Northern Rocky Mtn Forest-Steppe-Coniferous Forest-Alpine Meadow
(26) Ouachita Mixed Forest - Meadow
(27) Outer Coastal Plain Mixed Forest
(28) Ozark Broadleaf Forest - Meadow
(29) Pacific Lowland Mixed Forest
(30) Prairie Parkland (Subtropical)
(31) Prairie Parkland (Temperate)
(32) Sierran Steppe-Mixed Forest-Coniferous Forest-Alpine Meadow
(33) Southeastern Mixed Forest
(34) SRN Rocky Mtn Steppe-Open Woodland-Coniferous Forest-Alpine Meadow
(35) Southwest Plateau and Plains Dry Steppe and Shrub

Figure 5: Ecoregions of the United States: Alaska and Hawaii



2. B. 2. Mowing and brush hogging

HIGHLIGHTS

- Mowing and brush hogging can be valuable management tools for maintaining pollinator habitat
- Mow in late fall or winter after plants have bloomed and set seed
- Adjust timing to avoid vulnerable life stages of special status pollinators
- If pollinators are present, mow mid-day when adults can move out of the way
- Mow once every two to three years to keep natural areas open
- If areas must be mowed more frequently than every two years, minimize the area mowed
- Set blade height to 10 to 16 inches for most areas, and 2.5 inches for lawns
- Use a flushing bar and mow at speeds less than eight miles per hour
- Mow in patches on an alternating cycle to provide refugia for pollinators and ensure that some pollinator habitat is left intact

Mowing or brush hogging can be a valuable management tool to keep areas open and sunny to benefit pollinators. They can also be used to control some invasive plants (Section 2.B.6). Mowing and brush hogging are also common management tools for maintaining open areas adjacent to roadsides and under powerline rights-of-way (ROWs) that can provide important links between pollinator populations and food for migrating pollinators. The principles are the same for either method, so this section will use mowing to mean both mowing and bush hogging.

The timing, frequency and methods used for mowing will determine whether the open areas will benefit pollinators. Ill-timed mowing or mowing too frequently or too close to the ground can be detrimental to pollinators. Mowing too early in the season can prevent flowers from blooming, remove blooming flowers, cause mortality of insects feeding on or nesting in the plants, and prevent native plants from re-seeding. Mowing too close to the ground can kill pollinators feeding or overwintering on the plants (e.g., butterfly larvae or eggs) (Galea, et al., 2016; Hopwood, et al., 2015; USDA and DOI, 2015).

Timing of mowing - Ideally mowing should occur after plants have bloomed and set seed (late fall or winter). If this is not possible, either time mowing to encourage growth of most flowering plants (e.g., spring or summer depending on the area), or vary the timing of mowing to encourage a diversity of flowering plants. Adjust timing to avoid vulnerable life stages of special status pollinators. If an area must be mowed during the active season for pollinators, mowing during the middle of the day when it is warmer and pollinators are more active will lessen the impact of mowing (Hopwood, et al., 2015; Vaughan and Black 2007; USDA and DOI, 2015).

Frequency of mowing - Prairies, fields and some landscaped areas may only need to be mowed every two or three years to maintain sunny openings. Roadsides and powerline ROWs may need to be mowed more frequently for safety. If possible, only mow a narrow area near the road more

frequently to maintain clear lines of sight and reduce encroachment of deer or other large herbivores onto the roadway. Mow the remainder of the ROW less frequently to promote pollinators. Reducing mowing frequency will save time, money, reduce the carbon footprint, and reduce erosion (Hopwood, et al., 2015; Vaughan and Black 2007; Watkins, 2016).

Blade height - Adjust blade height to 10 to 16 inches to prevent direct mortality of pollinators feeding or nesting in the plants. For areas being maintained as lawns, adjust the mowing height to 2.5 inches and only mow every two to three weeks to increase the abundance of flowers (Hopwood, et al., 2015; USDA and DOI, 2015).

Flushing bars and reduced speed - Use a flushing bar and reduce mower speeds to less than eight miles per hour to reduce mower blade induced mortality (Hopwood, et al., 2015; USDA and DOI, 2015).

Mow in patches - Mowing in patches on an alternating cycle will leave refugia where pollinators can survive, and from which they can recolonize other parts of the site. This is especially applicable to natural areas that are mowed to keep them open and sunny. In natural areas, allow some areas to grow into shrubby patches, which provide nesting sites for native bees, and larval food for some butterflies and moths (USDA and DOI, 2015).

Brushhogging (photo: L. A. Mehrhoff/USFWS)

2. B. 3. Forest management

HIGHLIGHTS

- Forest habitat is important for some pollinators
- Replace nonnative trees and shrubs with native trees and shrubs
- Maintain and create openings in the forest
- Leave patches of open soil and some snags from thinning to provide pollinator nesting and overwintering habitat
- Use integrated pest management to control forest pests and reduce the use of pesticides

RELEVANT SECTIONS OF AFI

- AFI 32-7064, Chapter 12.5: Replace nonnative trees and shrubs, where native species will require less maintenance
- AFI 32-7064, Chapter 9.5.9: Use IPM to control or eradicate forest insects and diseases

Forest habitat is important for some pollinators (e.g., some hummingbirds, moth species that feed primarily on trees). Managing forest habitat to replace nonnative trees and shrubs will improve the habitat for pollinators. Replacing nonnative trees and shrubs is consistent with AFI 32-7064, Chapter 12.5, where native species will require less maintenance (Burghhardt, et al., 2009).

Managing the forest to keep open habitat patches within the forest will increase the diversity of pollinator species. Periodically remove saplings and some shrubs in these areas to keep the area open. Remove vegetation using mechanical cutting, cutting followed by herbicide stump treatment, targeted herbicide treatment (e.g., injection or basal bark application), or prescribed fires. The best method will depend on the situation. If there is a special status pollinator present, care should be taken not to remove tree species they are dependent on for survival (USDA and DOI, 2015).

Creating new openings by thinning trees to allow sunlight to reach the forest floor will benefit pollinators. Consult with a forester or other expert to determine the best areas for thinning and shrub control and techniques that minimize the risk of disease and wounding residual trees. If there are native species that provide benefit to pollinators, such as willow, cherry, redbud and sumac, leave some or all of them on site. Where there is a dense understory shrub layer or midstory, additional treatment will be necessary to remove or thin this layer. In some cases, native flowering plants will naturally grow once the area is open; in other cases, seeding may be necessary. If seeding is needed, see Section 2.B.1 for additional guidance. Where roads run through dense forest canopy, consider creating and maintaining some openings in the canopy alongside the road to encourage the growth of native flowering plants in the understory (Galea, et al., 2016; USDA and DOI, 2015).

Leave patches of open soil and some snags that result from thinning to provide nesting habitat for pollinators (USDA and DOI, 2015).

Use integrated pest management (IPM) (Section 3) to treat pest problems in forested areas. Many forest pests are insects, and insecticides used to control them may adversely impact pollinators. Use of IPM to control or eradicate forest insects and diseases is consistent with AFI 32-7064, Chapter 9.5.1.

Forest opening (photo: USFWS)

2. B. 4. Prescribed fire

HIGHLIGHTS

- Fire can be a valuable management tool for creating and maintaining pollinator habitat but will result in direct mortality of pollinators present during the fire
- Burning too much of the habitat, burning it too frequently or too intensely will likely reduce or eliminate pollinator populations
- Consider the needs of any pollinator species of conservation concern present and include them on the sensitive resources checklist
- Keep the burn size small enough relative to the surrounding habitat so that pollinators are able to recolonize
- In general, do not burn more than 30% of a site per year
- Allow enough time between prescribed fires so that pollinators have time to recover or reestablish populations
- Burning in late fall to early spring can minimize harm to pollinators overwintering in protected areas
- Varying the season of the burn may promote pollinator diversity
- Conduct burns when fuel conditions promote a mosaic pattern of burned and unburned habitat
- Avoid high intensity fires unless needed to meet habitat management goals

RELEVANT SECTION OF AIR FORCE INSTRUCTIONS

- AFI 32-7064, Chapter 13.3.8: Include a checklist of sensitive natural resources in Wildland Fire Management Plans

Prescribed fires can be a valuable management tool to increase habitat heterogeneity, enhance flowering plant diversity and abundance, limit certain invasive species, and maintain or restore open areas used by pollinators. It is an important tool for providing openings in forests and maintaining open habitats (e.g., prairies). Fire can be used to reduce fuel loads, control disease and pests, stimulate plant growth and recycle nutrients.

Proper planning and implementation is critical to benefit or prevent harm to pollinators. Pollinators present during a fire likely will not survive. Biologists and fire specialists will need to evaluate the pollinator populations and habitat needs on a case-by-case basis to determine burn area, timing, frequency and intensity. The goal is to promote habitat heterogeneity and flowering plant diversity and abundance while keeping the burn size small enough relative to the surrounding habitat so that pollinators are able to recolonize from surrounding areas. If the suitable habitat patches nearby are too small, less abundant pollinator species may be locally extirpated (Hopwood, et al., 2015; Mader, et al., 2011; USDA and DOI, 2015).

Special care is needed if special status species are known to occur in the burn area. There may be constraints on the timing of the burn or its location to prevent harming special status species.

AFI 32-7064, Chapter 13.3.8 requires Wildlife Fire Management Plans to include a checklist identifying sensitive natural and cultural resources that need to be considered before wildland fire management is allowed. Be sure to include pollinator species of conservation concern on that checklist.

Patch or ignition unit size - Consider the availability of existing suitable habitat in the surrounding landscape and the ability of pollinators to re-colonize from nearby unburned areas when determining appropriate patch or ignition unit size. Leave enough unburned habitat for the pollinator populations to recover. Creating mosaic patterns of burned and unburned habitat and/or leaving unburned islands is often recommended. In general, do not burn more than 30% of the habitat in a year. Breaking up units can be more important ecologically in landscapes with isolated conservation areas, but this must be balanced with potential increased operational complexities. Breaking up units may not be as necessary if there is a complex of unburned habitat nearby occupied by the same pollinator species (Hopwood, et al., 2015, Mader, et al., 2011; USDA and DOI, 2015).

Frequency - The frequency of prescribed fire will depend on the habitat type (e.g., grassland vs. forest) and management goals. Burning too frequently can reduce or eliminate pollinator populations. Consider habitat type and condition, pollinator recovery rates and habitat needs, patch size of the prescribed fire, and the habitat available in the surrounding landscape to determine the appropriate frequency (Mader, et al., 2011; USDA and DOI, 2015).

Timing - Direct mortality of pollinators can be reduced by considering pollinator life history and burn seasonality and timing. Burning in late fall to early spring can minimize harm to pollinators overwintering underground or in protected areas. Species such as bumble bees and many butterflies that overwinter in unprotected areas (e.g., on plant stems, in the duff, top layers of the soil, or in small twigs and stems) are not able to withstand burning. Summer burns are likely to be more harmful because they very likely will cause mortality of pollinators and eliminate flowers at a time when surviving pollinators are dependent on them for nectar. Varying the time of year of the prescribed fire may promote pollinator diversity. Take the needs of any pollinators of conservation concern present into account in determining timing (Hopwood, et al., 2015, Mader, et al., 2011; USDA and DOI, 2015).

Fire intensity - Implement firing patterns that regulate the burn's intensity. Conduct burns when fuel conditions promote a mosaic pattern of burned and unburned habitat and leave unburned islands. Unburned areas can provide refugia for pollinators. Avoid high intensity fires unless they are needed to meet habitat management goals (Mader, et al., 2011; USDA and DOI, 2015).

Fire fighter lighting prescribed fire (photo: Ryan Hagerty USFWS)

2. B. 5. Agricultural outlease activities

HIGHLIGHTS

- Integrate pollinator conservation practices into agricultural outlease agreements
- Include measures to control the spread of invasive plants in outlease agreement land use rules (Section 2.B.5)
- Require the use of IPM to reduce pesticide use and impacts (Section 3)

RELEVANT SECTIONS OF AFI

- AFI 32-7064, Chapter 10: Write land use rules for agricultural outleases to support natural resource goals and objectives
- AFI 32-7064, Chapter 14.4: Include requirements to prevent the introduction and spread of invasive species in cropland and grazing outgrant agreements
- AFI 32-7064, Chapter 6: Leaseholders are required to obtain Air Force permission prior to use of pesticides

Agricultural outleases on Air Force lands can include: crop production, livestock grazing, equestrian operations, commercial seed harvesting, apiary placement, maple sugar collection and other activities that are feasible and compatible with and support the goals and objectives of the installation INRMP. This section addresses crop production, haying, livestock grazing and equestrian operations, and apiculture. As with most land management activities there are practices that will benefit pollinators and others that will be detrimental to pollinators. For all of these activities AFI 32-7064, Chapter 10.2.4 provides for the ability to include land use rules with the outlease agreements to support natural resource management goals and objectives. Thus, practices beneficial to pollinators can be built into the outlease agreements. Use the sections below to develop appropriate land use rules.

Two concerns common to most agricultural activities are: (1) the potential to spread invasives plants that can crowd out native plants and (2) inadvertent impacts from pesticides on pollinators. See Sections 2.B.5 (Invasive species control) and Section 3 (Reducing pesticide use and adverse impacts of pest control) for measures to address these concerns that can be included in leaseholder agreements. AFI 32-7064, Chapter 14.4, specifies that cropland and grazing outgrant agreements will include requirements to prevent the introduction and spread of invasive species. Lease holders are required to obtain Air Force approval to use pesticides (AFI 32-7064, Chapter 6). Agreements could include use of IPM and other practices to reduce harm to pollinators.

HIGHLIGHTS

- Provide additional native flowering plants and bunch grasses
- Reduce soil disturbance
- Leave dead trees, branches and stems and grassy thickets
- Adjust timing of planting and clearing vegetation
- Use pest-resistant crops; do not use seeds pre-treated with pesticide

A healthy native pollinator population is beneficial for crop production. Native pollinators are important pollinators of some crops, such as squash, tomatoes, and blueberries. Increased native pollinator populations will reduce the need for farmers to rent or keep honey bee hives for crop pollination. In 2010, insect pollinators (excluding honey bees) in the U.S. contributed to the production of crops valued at $10 billion (Calderone, 2012). Land management practices on agricultural outleases can be modified to protect and enhance pollinator habitat, and reduce threats to pollinators.

Crops that are pollinated by insects and other animals will offer more opportunities for and benefits from pollinator conservation than wind-pollinated crops. Consider crop type, field size, and whether surrounding habitat supports pollinators in determining which conservation measures below are appropriate. Consider measures to minimize off-site impacts (e.g., from pesticide use) and increase nectar resources around fields if the surrounding habitat supports pollinators.

Provide additional native flowering plants and bunch grasses - Plant a diversity of native flowering plants favored by pollinators along fence rows and field edges, or as a cover crop (e.g., in orchards) to support pollinator populations. See Section 2.B.1, Selecting plants, for further information (USDA and DOI, 2015; Vaughan, et al., 2015).

Reduce soil disturbance - Use no-till seed drilling to reduce destruction and disturbance of ground-nesting bees while also minimizing weed growth. Lengthen crop rotation cycles and minimize weed control tillage to benefit ground-nesting bees. Reduce disturbance of well-drained areas with direct soil access (sparse vegetation) to provide nesting opportunities for ground-nesting bees. Avoid plowing or tilling in areas where bees are nesting (Mader, et al., 2011; USDA and DOI, 2015; Vaughan and Black, 2007; Vaughan, et al., 2015).

Adjust timing of planting and clearing vegetation - Stagger when crops with flowers are planted to have continuous blooms to support a greater variety of pollinators. If this is not possible, allow crops to flower before being plowed (Vaughan and Black, 2007; Vaughan, et al, 2015).

Leave dead trees, branches, and stems and grassy thickets - Leave dead trees, branches, stems and grassy thickets between crop plots or along field borders to provide nesting sites for some pollinators. Protect grassy thickets and other dense, low vegetation that provides nesting sites for bumble bees (Vaughan and Black 2007; Vaughan, et al, 2015).

Crop selection - Reduce use of pesticides by selecting pest-resistant crops when they are available and avoiding seeds pre-treated with pesticide.

HAYING

HIGHLIGHTS

- Harvest from one end of the field to the other
- Delay haying until after flowers bloom
- Limit haying to no more than 50 to 70% of the field
- Limit haying to no more than once per year and rotate area hayed annually
- Consider planting native flowering plants in and around hayfields

Haying may occur in areas ranging from stands of a single species of nonnative grass to native meadows with a variety of grasses and flowering plants. Haying may occur multiple times per year or once every several years. Areas with stands of a single species of nonnative grass will not support pollinators, but native meadows will. Frequent harvesting may eliminate pollinator habitat. The impacts to pollinators of haying are similar to those of mowing and brush hogging. Haying removes plants being used by pollinators for nesting, immature development stages, and feeding, and directly kills pollinators on the plants at the time of haying. (USDA and DOI, 2015; USFWS, 2015).

In areas where haying offers opportunities to conserve pollinators, the following measures are recommended.

Haying methods - Harvest from one end of the field to the other (rather than from the perimeter inward) to allow adult pollinators in the field to escape (USDA and DOI, 2015).

Haying timing, frequency, patch size and rotations - Delay haying until after any native plants in the field bloom when possible. Limit haying to once per year or less if the area supports flowering plants. Limit the area being hayed to 50 to 70% of the area with blooming flowers (including areas in and adjacent to the unit) to provide refugia for pollinators. The areas used as refugia either should be large enough to support both pollinator food sources and nesting sites, or within a few hundred feet of those resources. Rotate which areas are hayed each year to allow pollinator populations time to re-establish (USDA and DOI, 2015; USFWS, 2015).

Plant native flowering plants and bunch grasses - Consider planting native plants beneficial to pollinators in or around hayfields where appropriate and compatible with goals. See Section 2.B.1, Selecting plants, for further information. See note about milkweed toxicity in Section 2.B.1, Livestock grazing equestrian operations, if hay will be used for forage (USDA and DOI, 2015).

Hayfield (photo: Scrubhiker (USCdyer) CC BY-NC 2.0)

HIGHLIGHTS

- Grazing can benefit pollinators by maintaining or producing a mix of open and shrubby areas and helping to control invasive plants
- Heavy grazing can harm pollinators by reducing flowering plant abundance and diversity, compacting soils, and destroying pollinator nests found in soil
- Ill-timed grazing can dramatically reduce nectar and pollen available to pollinators and kill larval pollinators feeding on the plants being consumed
- Equestrian operations in high use areas can compact soils and reducing flowering plants
- Use rotational grazing to:
    - rest areas to reduce soil compaction
    - allow plants to flower and set seed
    - provide refugia for pollinators
    - promote habitat for butterfly egg and larvae development
- Maintain fencing to rest areas and protect important pollinator habitat
- Locate high use areas away from known concentrations of bee nests and pollinator host plants
- Re-seed or inter-seed with native plants beneficial to pollinators

HELPFUL WEBSITE

- USDA Service Centers: https://offices.sc.egov.usda.gov/locator/app

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 10: Livestock grazing programs must support the goals and objectives of the installation INRMP; not degrade natural ecological integrity; and rangeland health must be monitored

Livestock grazing can benefit pollinators by maintaining a mix of open and shrubby areas and helping to control invasive species. Grazing that is too intense, poorly timed for pollinators, or includes practices that increase invasive species can be harmful to pollinators. Heavy grazing can reduce plant abundance and diversity and compact soils. Soil compaction is also likely around high-use areas such as in holding corrals, water tanks and salt/mineral blocks. Heavy grazing can destroy the nests of pollinators, such as bees, found in the soil. Ill-timed grazing can dramatically reduce nectar and pollen available to pollinators and kill larval pollinators (e.g., butterfly larvae) feeding on the plants being consumed. Livestock may carry invasive species from one area to another when grazing areas are rotated. Equestrian operations, particularly along trails and around water tanks, can compact soil and reduce flowering plants (Hatfield, et al., 2012; Mader, et al., 2011; USDA and DOI, 2015).

Livestock grazing programs on Air Force lands must not degrade the natural ecological integrity of the landscape, and be monitored to determine rangeland health (AFI 32-7064, Chapter 10).

The following measures can be implemented to lessen impacts to pollinators from livestock grazing and equestrian operations.

Rotate grazing - Rotate grazing areas and timing using interior cross-fencing to subdivide grazing areas to: (1) reduce damage to bee nests from soil compaction; (2) allow native plants to flower and set seed, providing nectar and pollen for pollinators; (3) prevent grazing in areas when butterfly eggs and larvae are present or when nectar resources are scarce; (4) leave 30 to 75% of the habitat free of grazing as a refugia for pollinators; and (5) maintain healthy open, herbaceous plant communities with 50% of vegetative growth maintained on all plants (Mader, et al., 2011; USDA and DOI, 2015; USFWS, 2015). USDA Service Centers typically have grazing specialists available to provide technical assistance developing grazing management plans.

Maintain fencing - Maintain fencing to rest areas to benefit pollinators and protect important pollinator habitat. Add interior cross-fencing to promote rotational grazing where applicable (USDA and DOI, 2015; USFWS, 2015).

Locate high use areas away from important pollinator habitat - Place water tanks, salt/mineral licks, corrals and/or trails away from known concentrations of bees nests and pollinator host plants (USDA and DOI, 2015; USFWS, 2015).

Re-seed areas with native plants beneficial to pollinators - Consider including native flowering plants used by pollinators when grazing areas are re-seeded. See Section 2.B.1, Selecting plants, for further information. Note that milkweed plants can be toxic to livestock, but generally are only a problem when livestock is concentrated in an area with poor forage and abundant milkweed (Monarch Joint Venture, 2016).

L to R: Grazing (photo: Jeff Vanuga/USDA, NRCS)**; Honey bee on watermelon** (photo: USDA, ARS)

HIGHLIGHTS

- Honey bees are important to agriculture and their conservation is included in the Presidential Memo and *National Pollinator Strategy*
- Honey bees can transmit disease to native bees, increase seed set of invasive plants, and compete with other pollinators for nectar
- Consider the above factors in determining whether apiculture is appropriate for the area
- Locate honey bee hives two to five miles from sensitive pollinator or plant resources and flowering invasive plants

Honey bees are an important part of agriculture as crop pollinators, although they are not native to the U.S. In 2010, honey bees contributed to production of crops valued at nearly $19 billion. Unlike native bees, honey bees live in large perennial colonies. Each hive typically has 10,000 to 30,000 workers. They typically forage within two to five miles of their hive, but can forage over eight miles from their hive. Conservation of honey bees is part of both the Presidential Memo and the *National Pollinator Strategy* (Calderone, 2012; NRC, 2007; USDA and DOI, 2015).

There are several considerations about where to locate honey bee hives, especially if large numbers of hives are involved. Honey bees may impact natural areas by transmitting disease to native bees, increasing seed set of some invasive plant species (e.g., yellow star-thistle, *Centaurea solstitialis*), and competing with native bees and other pollinators for nectar and pollen. Decisions on whether or not to locate honey bees hives on Air Force managed lands should be made on a case-by-case basis considering the local area and land management goals (Barthell, et al., 2001; Goulson, 2003; Graystock, et al., 2016; Morkeski and Averill, 2010; Thomson, 2004; Thorp, 1996; USDA and DOI, 2015).

Locate honey bee hives two to five miles from sensitive pollinator or plant resources and flowering invasive plants - The goal is to locate honey bee hives so that when they are foraging within typical ranges from their hive, they do not encounter pollinator species of conservation concern or rare plant communities that may support rare pollinators. This is will minimize the spread of disease and competition for nectar and pollen. Locating hives this distance from flowering invasive plants under an active control program will minimize potential problems with honey bees increasing seed set (USDA and DOI, 2015).

2. B. 6. Invasive species control

HIGHLIGHTS

- Eliminate or control invasive plants to improve pollinator habitat
- Work first in areas without invasive species to prevent their spread
- Clean equipment to prevent the spread of invasive plants and their seeds.
- Use mechanical controls for invasive plants, such as hand-cutting and mowing
- Reduce and modify herbicide use to control invasive plants
- See Sections 1.B.2 (Mowing and brush hogging) and 1.B.4 (Prescribed fires), if these techniques are being considered to control invasive plants
- Consider using biocontrol to control widespread invasive plants
- Reduce and modify insecticide use by using IPM techniques to control pest insects

HELPFUL WEBSITE

- USDA Extension Offices: https://nifa.usda.gov/land-grant-colleges-and-universities-partner-website-directory?state=All&type=Extension

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 14: Address invasive species management in a "cost-effective, environmentally sound manner whenever and wherever practical" to promote and restore native habitat and species

Eliminate or control invasive plants to improve pollinator habitat. Although invasive plants may provide nectar and pollen for generalist pollinators, they can reduce plant diversity and crowd out native flowering plant species. This can reduce or eliminate food required by specialist pollinators. Invasive plants can alter essential habitat features. They can eliminate open ground habitat for nesting, and habitat complexity that provides shelter for pollinators. Eliminating or controlling invasive plant species benefits pollinators when done in a manner that limits harm to pollinators. Removal of invasives can harm pollinators if: (1) they, or the native plants they depend on, are also killed; (2) nectar sources are removed at critical times; or (3) nesting sites are disrupted (Anderson and Bailey, 2010; Burghardt, et al., 2009; CEQ, 2014; Hopwood, et al., 2015).

Careful planning is required when pollinators are using invasive plants for nectar or nesting and native plant species are not available. For example, in the west, invasive eucalyptus (*Eucalyptus* spp.) is used in some areas by migrating hummingbirds for nectar and by monarch butterflies for overwintering. If the eucalyptus is being used by pollinators and native plant species are not available nearby, preventing the spread of the eucalyptus may be more practical than removal. Complete elimination may require years of planting native species to replace the eucalyptus prior to removal of the eucalyptus (Centre for Agriculture and Biosciences International (CABI), 2017; Clark and Mitchell, 2013; Frey and Schaffner, 2004; Stanturf, et al., 2013).

Removal of invasive species is consistent with Chapter 14 of AFI 32-7064, which instructs installations to address invasive species management in INRMPS in a "cost-effective, environmentally sound manner whenever and wherever practical" and promote and restore native habitat and species.

Work first in areas without invasive species and clean equipment - Work in the areas without invasive species first to prevent spreading them to new areas. Clean vehicles travelling off-road, mowers, and other such equipment, when moving from one area to another, especially if moving from an area with an invasive species to one without. Make sure to clean all plant parts (e.g., roots and seeds) from equipment (USDA and DOI, 2015).

Use mechanical controls for invasive plants, such as hand-cutting and mowing, where effective - Common techniques for removal of invasive plants include frequent mowing, hand-cutting, prescribed fires, and flooding. Use mechanical controls where effective to control and/or eliminate invasive plants. Mowing and hand cutting are likely to have less impact on pollinators than prescribed fires, flooding and herbicides. In grasslands or prairies, mowing the revegetated area with a blade height of six inches in the first fall after planting will reduce weed reproduction. Consider mowing only the patches of habitat with weeds, if weeds are not extensive, nor particularly competitive. Along roadsides, it may be necessary to mow with a blade 10 inches above the ground several times during the first season to reduce weeds. See Section 2.B.2 (Mowing and brush hogging) and Section 2.B.4 (Prescribed fires) for tips on minimizing impacts to pollinators from these techniques (CEQ, 2014; Hopwood, et al., 2015; USFWS, 2015).

Reduce and modify herbicide use for invasive plant control - Herbicides are often used alone or in combination with mechanical controls to control or eliminate invasive plants. Improperly used herbicides can kill the native plants that pollinators depend on, directly harm pollinators, weaken native vegetation and lead to herbicide resistance in invasive plants. Reducing dependence on herbicides may also save money. When using herbicides to control invasives: (1) apply during the time when the invasive plant is most vulnerable (e.g., seedling or rosette stage); and/or (2) apply before invasive plants flower (reduces pollinator exposure and may result in more effective control). If herbicides are used for long-term control, it may be necessary to alternate between more than one herbicide to reduce problems with herbicide resistance. See Section 3 for more information on reducing impacts to pollinators from herbicide use (Hopwood, et al., 2015; USDA and DOI, 2015).

Biocontrol - an alternative to herbicides to control some invasive plants - One tool to reduce reliance on herbicides is biological control (See Section 3.D.3 for a definition). Biocontrol agents can be used effectively to control invasive plants that are so widespread that eradication is not likely. Biocontrol agents are inexpensive to purchase and self-propagating, making them less expensive than pesticide use for long term control. Biocontrol agents can spread diffusively to infested areas difficult to reach by conventional means. In the United States biological control agents are federally permitted. Examples of federally permitted biocontrol agents that have proven effective for habitat improvement are:

1. *Galerucella calmariensis* beetle targeting purple loosestrife (*Lythrum salicaria*)
2. *Rhinoncomimus latipes* beetle targeting mile-a-minute weed (*Persicaria perfoliata*)
3. *Cyrtobagous salviniae* targeting giant salvinia (*Salvinia molesta*) in Texas and Louisiana

Contact the USDA Extension Office in the state for local information on biocontrol agents and their use (Center for Aquatic and Invasive Plants, 2017; Flores and Carlson, 2006; Hough-Goldstein, et al., 2015; Olkowski, et al., 1991; FS, 2009; Wilson et al., 2004).

Reduce and modify insecticides used to control insect pests - Insecticides are often used to control outbreaks of insect pests. Insecticides are likely to kill or harm pollinators, and when overused can result in resistance of the pest species to the insecticide. Use IPM to reduce impacts to pollinators of pest insect control. The control methods will vary with the pest species, but generally, using cultural, mechanical and/or biological controls will reduce the need to use pesticides for control. If pesticides are needed, careful selection of the pesticide, formulation, application method and timing can help to minimize impacts on pollinators (Section 3).

Purple loosestrife, an invasive plant with a federally permitted biocontrol agent (photo: National Park Service)

2. B. 7. Golf course management

HIGHLIGHTS

- Include management prescriptions favorable to pollinators in the Golf Course Environmental Management (GEM) Plan
- Reduce mowing in out-of-play areas
- Plant additional native flowering plants and bunch grasses in out-of-play areas and as buffers around water hazards
- Manage habitat to provide nesting and overwintering sites for pollinators
- Reduce and modify pesticide use
- Avoid use of methyl isothiocyanate
- Remove invasives plants

RELEVANT SECTION OF AFI

- AFI 32-7064, Chapter 12.4: A Golf Course Environmental Management Plan (GEM Plan) should "minimize or eliminate potential negative impacts to the environment and the surrounding community"

lf courses provide an opportunity for maintaining and enhancing pollinator habitat. Even small patches of habitat (e.g., out-of-play areas) can help support pollinators. Reduce mowing, plant native flowering plants and bunch grasses, remove invasive plants, and reduce pesticide use to support pollinator conservation. Installations that have a Golf Course Environmental Management (GEM) Plan associated with their INRMP will have an opportunity to include management prescriptions favorable to pollinators. The goal of a GEM Plan is to "minimize or eliminate potential negative impacts to the environment and the surrounding community" (AFI 32-7064, Chapter 12.4) (Shepherd, 2002; and Watkins, 2016).

Reduce mowing in out-of-play areas - Mowing can be a valuable tool for maintaining open areas that are used by pollinators, but timing, frequency and techniques used will determine whether or not it will be beneficial to pollinators. If mowing occurs before flowers have bloomed, it will reduce available nectar for pollinators. Reduced mowing will reduce fuel and labor costs, the carbon footprint, and erosion and water use. See Section 2.B.2 (Mowing and brush hogging) for best management practices for pollinators (Watkins, 2016).

Provide additional native flowering plants and bunch grasses in out-of-play areas - Plant a diversity of native flowering plants in out-of-play areas and as buffers around water hazards. Buffers should be at least the length of a golf driver wide. Use native plants to connect areas that provide suitable habitat for pollinators. Adding bunch grasses will provide nesting sites for some bees and roosting sites for butterflies. See Section 2.B.1 for information on plant selection. Select species that may not grow so densely as to present a barrier if players will enter out-of-play areas frequently to retrieve balls (Shepherd, 2002; Watkins 2016).

Manage habitat to provide nesting and overwintering sites for pollinators **-** See Section 2.B.1 (Providing nesting and overwintering habitat) for suggestions on how to manage habitat in out-of-play areas to provide nesting and overwintering sites for pollinators. Well-drained sand pits, or even sand piles (less than two feet tall), will sometimes be used by bees for nesting (Shepherd, 2002).

Reduce and modify pesticide use to reduce exposure and toxicity - Pesticide use should be reduced to the greatest extent possible using IPM. In downslope areas, where pesticide from upslope may naturally runoff, it may be possible to reduce application rates. Avoid use of methyl isothiocyanate. See Section 3 for information on reducing pesticide use and impacts (Watkins, 2016).

Remove invasive plants - See Section 2.B.6 for information about invasive species control.

Golf course with pollinator plantings (photo: Wedge Watkins/USFWS)

2. B. 8. Construction

HIGHLIGHTS

- Construction can destroy native plants and pollinator nests
- Limit areas where heavy equipment travels and operates
- Salvage native plants or collect their seeds
- Use native plants for landscaping near buildings and parking lots

Construction and other development can impact pollinators through disturbance and loss of habitat and soil compaction. Both native plants and pollinator nesting sites can be destroyed by construction. Minimize the areas where heavy equipment travels and operates to minimize these impacts. Salvage or collect and store seeds from native plants that will be destroyed by construction if pollinator habitat restoration is planned nearby or for use in future projects. Use native landscaping around new buildings, parking lots, and other areas when construction is complete to replace some of the habitat lost. See Section 2.B.1 for information on landscaping.

SECTION 3: REDUCING PESTICIDE USE AND ADVERSE IMPACTS OF PEST CONTROL

This section provides information on how to effectively control pests while reducing pesticide use and the adverse impacts of pest control to pollinators. Pesticide use must be addressed in habitats where pollinator conservation is a goal. This section describes IPM, the importance of monitoring and setting thresholds, and alternatives to pesticide use, such as cultural, physical and biological control. It also discusses practices to minimize pesticide toxicity and reduce exposure when pesticide use is necessary. A table with common cultural, physical and biological control methods for common pests is provided. There is also a table that provides information on acute toxicity of pesticide active ingredients to bees. This information can be used in preparing and coordinating IPMPs and INRMPs.

Pesticides (including insecticides, herbicides, and fungicides, among other compounds) can kill more than the target pest and are one of multiple factors contributing to the decline of native pollinators and honey bees. Some ways insecticides and some herbicides can harm pollinators are by killing them, delaying development, reducing reproduction, and affecting the ability to forage and navigate. Pesticide residues can remain in the environment and be effective on targeted and non-target animals for days after it is applied. They can be absorbed and transported to plant parts including leaves, nectar, and pollen and even exuded as droplets by plants. Pollinators can ingest the pesticides by eating plant parts or drinking the liquid exuded by the plant (EPA, 2016d; EPA, 2016e; Fischer and Moriarty, 2014; Grozinger and Evans, 2015; Hooven et al., 2013; NRC, 2007; Stark, et al., 2012; Vaughan, et al., 2015; and Yu, 2008).

Herbicides can indirectly harm pollinators by eliminating their food source. They can also disrupt the balance of predators and parasites that naturally regulate pest problems. Pest problems can increase when pesticides are used if the pesticide kills natural predators (e.g., beneficial insects) along with the target pest, or if the target pest develops resistance to the pesticide (Hemingway, et al., 2002; Hooven et al., 2013; Stark, et al., 2012; Insecticide Resistance Action Committee (IRAC) and Southern Region Integrated Pest Management Center (SRIPMC) (no date); and Yu, 2008).

In habitats where successful pollinator conservation is a goal, the following two-tiered approach is recommended to minimize harm to pollinators from pesticides:

1. Eliminate the use of pesticides when possible.
2. Target the use of pesticides to the specific pest problem when pesticides are necessary to achieve management goals.

This approach will minimize the adverse effects of pesticide use on pollinators and other non-target organisms. Existing Federal strategies and policies support this approach, including the Presidential and Under Secretary of Defense Memos, the Armed Forces Pest Management Board (AFPMB), and the Air Force Pest Management Program. This section of the *Reference Guide* provides information on using IPM to reduce dependence on pesticides and minimizing their impacts.

SECTION 3. A. WHY USE INTEGRATED PEST MANAGEMENT (IPM)?

HIGHLIGHTS

- IPM minimizes threats to pollinators from pesticides
- IPM is a widely used, long-standing, science-based approach to managing all kinds of pests supported by the Air Force Pest Management Program
- Reducing pesticide use can save money
- Work with contracting officers to ensure pest management contractors are using IPM
- Coordination of IPMPs for outdoor areas with INRMPs is essential for successful pollinator conservation

RELEVANT SECTIONS OF AFI

- AF 32-1053, paragraph 1: IPM reduces pollution and other risk factors
- AFI 32-1053, paragraph 2.4: IPM is an objective of the Air Force Pest Management Program
- AFI 32-1053, paragraph 3.7.5.5: INRMPs and IPMPs should be coordinated with USFWS when listed species are present
- AFI 32-1053, paragraph 3.8.5: INRMPS and IPMPs should be coordinated with USFWS in accordance with the Sikes Act
- AF1 32-1053, paragraph 4.7: All pest management contractors are required to use IPM identified in the IPMP
- AFI 32-7064, Chapter 12: Natural resource and pest management personnel should coordinate so that INRMPs and IPMPs are mutually supportive

The threat to pollinators from pesticides can be minimized by using an IPM approach that reduces the need for pesticides and the likelihood of inadvertent pollinator kills or sublethal effects from pesticides. IPM is a widely used, long-standing, science-based approach to managing all kinds of pests effectively by combining physical, biological, cultural, and chemical tools in a way that minimizes risks to people, the environment and economic impact. IPM practices have been developed to improve pest control while minimizing impacts on beneficial species, such as pollinators. IPM helps maintain a balanced ecosystem, where pollinators and other beneficial insects, that provide natural pest control, can thrive. Reducing the amount of pesticides used and time spent applying pesticides through IPM can also save money. IPM is

one of the objectives of the Air Force pest management program, which "reduces pollution and other risk factors" (AFI 32-1053, *Integrated Pest Management Program*, paragraphs 1 and 2).

Work with contracting officers as pest management contracts come up for renewal to ensure outdoor pests are being managed using IPM rather than with routine spraying on lands where pest management is contracted. AFI 32-1053, paragraph 4.7 states "All pest management contractors must use IPM identified in the installation pest management plan …"

Finally, for IPM to be fully effective in supporting pollinator conservation, the pest management professional must coordinate the IPMP for outdoor areas with the natural resource manager to assure the goals and objectives of the installation INRMP for those areas will be met. This approach is supported by AFI 32-7064, Chapter 12, "Natural resources managers will coordinate with pest management personnel to ensure that the IPMP and INRMP are mutually supportive and not in conflict." INRMPs and IPMPs also need to be coordinated with USFWS and the state fish and wildlife management agency in accordance with the Sikes Act, and when federally listed species are present (AFI 32-1053, paragraph 3.8.5 and AFI 32-1053, paragraph 3.7.5.5).

***Aedes spp.* mosquito, a vector of human disease** (photo: USDA, ARS)

SECTION 3. B. ELEMENTS OF IPM

HIGHLIGHTS

- The elements of integrated pest management (IPM) are:
  - Describe the pest problem
  - Identify and describe the site and its ecology and management goals for the habitat and the pest
  - Know the pests and their natural enemies
  - Prevent pests at your site
  - Monitor the pest
  - Establish an action threshold (the level of damage or number of pests at which a pest control measures will be implemented)
  - Decide what methods, strategies, or tools will be used to control the pest
  - Notify neighbors, such as beekeepers, who may be affected by onsite pest management actions
  - Implement the lowest risk, most effective methods and tools. Conserve natural enemies of the pest
  - Evaluate the results and adapting and modifying the strategy, as needed.
  - Keep records

RELEVANT SECTION OF AFI

- AFI 32-1053, Integrated Pest Management Program

Implementation of an integrated pest management (IPM) program involves being able to clearly describe the pest problem that needs to be addressed (e.g., a health hazard, economic damage, etc.), including its effect on the site, resource, or human health. Once the pest problem is defined, then identify and describe the site, its ecology and the management goals for the habitat and the pest. Be sure to include a description of any sensitive plants or animals or water sources at the site that will need to be considered in designing a management program. Management goals for the pest may range from control to complete eradication. Resource goals could be conserving pollinators, improving conditions for training exercises, etc. (Olkowski, et al., 1991; USFWS, 2003).

It is important to understand the biological and physical conditions (water, food, shelter, temperature, and light) that support the pest and its natural enemies, and how to make conditions more attractive to beneficial insects, and less attractive to the pest. This information may elucidate possible control measures. This information may be used to exclude the pest from the site. Prevention should be the first line of defense. Typically, cultural or physical methods of control are used to prevent pests from reaching the site (USFWS, 2003; USFWS, 2013).

Monitoring is an important part of IPM. It is used to both establish action thresholds and evaluate effectiveness of the control measures. An action threshold is the level of damage or number of pests at which a management strategy will be implemented to reduce the pest

population. Only implement control measures when the pest or pest damage reaches the action threshold. This will prevent unnecessary treatment (Olkowski, et al., 1991; USFWS, 2013) (Section 3.C).

Decide what methods, strategies, or tools will be used to control the pest. Physical, mechanical, biological, and chemical methods are potential options. Typically a combination of methods will be selected. See Sections 3.D and 3.E regarding control methods (USFWS, 2013).

Neighbors who may be affected by onsite pest management actions, such as beekeepers, should be notified before beginning a control program. Then implement the lowest risk, most effective methods and tools in accordance with applicable laws, regulations, and policies. Conserve pollinators and natural enemies of the pest while implementing control measures. Continually evaluate the results using quantitatively monitoring to determine if the objectives have been achieved (Section 3.C). If the objectives have not been achieved, modify the strategy. Always record methods implemented, action thresholds, monitoring data, results achieved and any modifications. This information can be used to make future decisions on effective IPM strategies. AFI 32-1053 provides additional details (USFWS, 2013).

Dip sampling for mosquito larvae (photo: Don Brubaker/USFWS)

SECTION 3. C. MONITORING AND SETTING THRESHOLDS

HIGHLIGHTS

- Use monitoring to establish a quantitative action threshold
- Monitoring may be used to better understand the pest problem
- Set a quantitative action threshold to determine when to treat a pest problem
- Use quantitative monitoring that has specific, measurable, achievable, realistic, and time-based objectives to determine when treatment is necessary and effectiveness of treatment
- Monitor the pest stage that can be most effectively controlled
- Consider the effect of the pest when deciding whether to monitor pest numbers, damage level or pest sign
- Common monitoring methods are:
    - scouting and recording observations
    - collecting data from traps
- Record information on the natural enemies of the pest, relevant human activity in the area, and weather when collecting monitoring data

HELPFUL WEBSITE

- Centers for Disease Control and Prevention Mosquito control website (information on monitoring and control): https://www.cdc.gov/westnile/faq/mosquitocontrol.html

RELEVANT SECTION OF AFI

- AFI 32-1053, paragraph 3: Pest management operations must be based on appropriate surveillance data

Cornerstones of IPM are monitoring and setting action thresholds. Use the monitoring data to establish an action threshold. Conduct monitoring before treatment to determine when the threshold for treatment is met. Monitoring can also provide early detection of pests, information on how they are getting to the resource, conditions that may be fostering the problem, and if the pest is harming people (Olkowski, et al, 1991).

Action thresholds are set to determine whether to treat for pests so that treatment only occurs when actually needed. This approach keeps pests under control while minimizing harm to non-targets, such as pollinators. The thresholds may be based on human health concerns (e.g., transmission of pathogens that cause disease), structural damage to facilities (e.g. termite damage to wood), aesthetic damage (e.g., severe defoliation on landscape plants), economic damage (e.g., damage to crops on agricultural outleases), or nuisance problems (e.g., birds nesting in the eaves of buildings). Complete elimination or prevention of pests is typically not the goal – the exceptions may be with human health concerns or efforts to exclude invasive species that have just arrived in the area. Using thresholds to determine when to treat is cost efficient and ensures

greater success because of reduced impacts on non-targets that may be helping to control the target pest (Olkowski, et al., 1991).

Monitoring post-treatment provides the information needed to adjust future pest management strategies to increase effectiveness. Use quantitative monitoring that has specific, measurable, achievable, realistic, and time-based objectives to determine when treatment is necessary and effectiveness of treatment. This approach is consistent with AFI 32-1053, paragraph 3, which states "All pest management operations must be based on appropriate surveillance data . . ."

When designing a monitoring routine identify which pest life stage can be most effectively controlled and design a monitoring protocol for that life stage. Sometimes it may be necessary to monitor more than one life stage. For example, the most effective control for mosquitoes is conducted when they are in the larval stage. Routine monitoring of standing water for mosquito larvae will allow treatment before mosquitoes reach the adult stage. However, if the spread of mosquito borne disease is a concern, it may also be necessary to monitor for adult mosquitoes to determine effectiveness of control (Mazzacano and Black, 2013; Olkowski, et al., 1991).

Consider what the effect of the pest problem is when deciding exactly what will be monitored in designing a monitoring program. Quantitative monitoring can be for pest presence (e.g., number of individuals), damage levels (e.g., percent defoliation), and/or pest sign (e.g., droppings). Deciding exactly what to monitor will depend on the pest, the problem the pest is causing, and sampling efficiency (Olkowski, et al., 1991).

Monitoring methods can vary from casual observation to statistically valid quantitative sampling. In most situations, a middle-ground approach of regular written observations with quantitative sampling on a regular basis will balance the usefulness of the data with the cost of monitoring. Common monitoring methods include (1) a "scout" going out and looking for pests and recording their observations or (2) periodically gathering data from traps (e.g., sticky traps, pitfall traps) or lures (with pest attractants). Use consistent methods for monitoring each pest problem (Olkowski, et al., 1991).

It is also important to record observations of the natural enemies of the pest, relevant human activity in the area, and weather when collecting monitoring data. All of these factors are important to pest control. Abundant natural enemies can help keep the pest under control, and weather will impact pest reproduction and survival. Observation of human activities that may be contributing to the pest problem (e.g., leaving standing water in areas where mosquitoes are a concern) can be used to develop and implement cultural and physical methods to control the pest (Olkowski, et al., 1991; USFWS, 2013).

SECTION 3. D. ALTERNATIVES TO PESTICIDE USE

HIGHLIGHTS

- Use cultural, physical, mechanical, and biological methods to control pests
- Evaluate opportunities to minimize pesticide use while maintaining mission support requirements

HELPFUL WEBSITES

- Armed Forces Pest Management Board (AFPMB) publications: http://www.acq.osd.mil/eie/afpmb/products.html
- National Park Service - IPM Manual: http://www.nature.nps.gov/biology/ipm/manual/ipmmanual.cfm
- U.S. Department of Agriculture/Animal and Plant Health Inspection Service Pest Control Manuals: https://www.aphis.usda.gov/aphis/ourfocus/planthealth/complete-list-of-electronic-manuals

RELEVANT SECTION OF AFI

- AFI 32-1053, paragraph 4.5.5: Evaluate opportunities to minimize pesticide use while maintaining mission support requirements

Cultural, physical and mechanical methods of pest control that achieve management goals should be used before pesticides. This will avoid any potential impacts from pesticides, such as directly harming pollinators and the plants they depend on for nourishment and raising young. Exploring alternatives to pesticides is consistent with AFI 32-1053, paragraph 4.5.5, which requires evaluation of "opportunities to minimize the use of pesticides while maintaining mission support requirements in accordance with the DoD Strategic Sustainability Performance Plan." Furthermore, overuse of pesticides may result in resistance of the pest to the pesticide.

Some non-chemical options to control pests are:

1. Remove food and other conditions that attract the pest.
2. Encourage native predators and parasites that may keep the target pest in check.
3. Eliminate habitat for the pest.
4. Exclude the pest from the area of concern.
5. Mechanically kill or remove the pest.
6. Use lawfully approved biocontrol organisms.

3. D. 1. Cultural controls

HIGHLIGHTS

- Cultural controls should be a first line of defense against pest problems
- Cultural control methods focus on changing human behavior or modifying the landscape/environment to reduce or eliminate breeding sites and food sources for pests

Cultural controls are practices that reduce establishment, reproduction and survival of the target pest and should be a first line of defense against pest problems. Cultural controls rely on changes in human behavior and modification of the landscape or pest environment to effect source reduction. Understanding the pest and its environment and the impact of human behavior on these are key to successfully implementing cultural controls to prevent or control pests. Methods of cultural control of pests will be specific to the pest problem (AFPMB, 2016; Olkowski, et al., 1991; University of California (UC), 2016). See Table 10 for pest-specific suggestions. The following provides an overview of methods of cultural control of pest problems.

Changing human behavior - Changes in human behavior can reduce or eliminate breeding sites and food sources for pests. Some examples include: (1) emptying and scrubbing containers with standing water at least weekly to eliminate mosquito breeding areas; (2) regularly inspecting and cleaning eaves and overhangs to prevent establishment of wasp nests; and (3) sealing containers of discarded garbage to reduce populations of scavengers (AFPMB, 2016; CDC, 2016; Olkowski, et al., 1991).

Human behavior can be modified to reduce exposure to the pest when complete control of the pest is not possible. Examples of this strategy are: (1) tucking pant legs in socks to prevent ticks from embedding and (2) using insect repellent to prevent mosquito bites (AFPMB, 2012; AFPMB, 2016).

Changes in human behavior can help to prevent introduction or reduce the spread of pests. An example of this is cleaning equipment when leaving areas infested with invasive plants to prevent their spread. The success of these methods requires support and cooperation of base personnel and may require education and outreach (Olkowski, et al., 1991).

Change water in bird baths twice weekly to remove breeding mosquito larvae (photo: Macomb Paynes/CC BY-NC-SA 2.0)

Modifying landscape - Modifying the landscape or ecosystem where the pest is present to reduce nesting sites or food sources can also go a long way toward reducing or eliminating pests. Examples of this technique include: (1) mowing grass along frequently travelled pathways to reduce tick abundance; (2) removing stacks of wood to eliminate nesting sites for rodents, termites and other potential pests; and (3) diversifying landscaping plant species to prevent overpopulations of pests (AFPMB, 2012; Mazzacano and Black, 2013; Olkowski, et al., 1991).

Landscape modification can be more extensive than the simple measures described above. A variety of landscape measures can be used in altered water systems to both reduce mosquito breeding areas and restore hydrologic function. The goal of many of these actions is restoring natural water circulation, which can reduce mosquito eggs and larvae before they hatch to adults. Modifications can involve:

1. Removal or replacement of weirs, dams, or missing or undersized culverts that inhibit natural water flow.
2. Managing tidal marsh habitat so that it drains, effectively interrupting the mosquito life cycle.
3. Restoring or creating high marsh ponds to serve as reservoirs for fish (such as mummichog (*Fundulus heteroclitus)* in coastal salt marshes) that control mosquito larvae.
4. Maintaining or restoring the meander and streambed topography to prevent pools that provide habitat for mosquito breeding.

Manipulation of unaltered wetlands should not be conducted because of their well-documented function and ecosystem values (Mitsch and Gosselink, 2015; Rochlin, et al., 2012).

Marsh with drainage ditches (photo: CDC)

Physical removal of an invasive plant
(photo: Ryan Hagerty/USFWS)

3. D. 2. Physical and mechanical controls

HIGHLIGHTS

- Physical and mechanical control methods include:
  - manual removal
  - trapping
  - installing barriers to exclude the pest

Physical and mechanical controls are methods that physically exclude or remove a pest, or kill it using physical means, including traps, barriers, and mowers. These methods can be successful either to reduce pest numbers, or eliminate pests at the start of an infestation (UC, 2016). See Table 10 for pest-specific suggestions. The following provides an overview of some methods of physical and mechanical pest control.

Manual removal - Manual removal methods are simply physical removal of a pest. This is done frequently with invasive plants. Small infestations can be stopped by hand-pulling while larger infestations can be controlled or reduced with frequent mowing or prescribed fires. Insects can be removed by vacuuming them up or using other devices to collect them (e.g., calling a beekeeper to remove honey bee nests or swarms from areas where they are not wanted by live capturing them). See Table 10, Swarming bees, footnote 22 for contacts (Olkowski, et al., 1991).

Trapping - There are many types of traps available specific to the target pest. Examples include snap-traps that kill rodents and traps for yellow jackets in picnic areas. Often traps will include a bait (such as food) to attract the pest (Olkowski, et al., 1991).

Barriers - Creating a barrier to exclude the pest from its breeding or feeding site is another physical control. Examples include painting or otherwise sealing wood to prevent carpenter bees from nesting in it, putting screens over open containers of water to keep out mosquitoes, and using mulch to prevent weeds from growing between garden plants (Olkowski, et al., 1991).

3. D. 3. Biological controls

HIGHLIGHTS

- Biocontrol methods:
  - encourage natural enemies by maintaining a healthy, balanced habitat
  - use pheromones to lure a pest into a trap
  - introduce natural enemies or disease organisms
  - control host populations
  - introduce sterile pest individuals
  - introduce other modified pest individuals, may be possible in the future

Biological control methods focus on the enhancement or release of natural enemies, such as predators, herbivores, parasites, parasitoids, disease organisms, and sometimes competitors, to control pests (UC, 2016). Biological control is another form of pest management where understanding the pest and its environment is key to successfully manipulating the pest environment to bring about control. There are a wide variety of biological control methods, ranging from general practices that encourage a healthy, balanced, diverse habitat to species-specific methods, like the introduction of nonnative species to control an animal pest or weed. See Table 10 for pest-specific suggestions. The following provides an overview of some methods of biological control of pest problems.

Use a pheromone to lure a pest into a trap - Pheromones are chemicals used as signals within a species for things like attracting a mate or providing a trail to a food source. Pheromones are available for many crop pests, especially moths and flies. It has recently been reported that some lures intended for other insects are attracting bumble bees. In areas with declining bumble bees extreme caution should be used if the lures lead to a lethal trap (Olkowski, et al., 1991; Jamie Strange, pers. comm., 2016).

Provide a healthy, balanced, diverse habitat to increase natural enemies (native predators, herbivores, parasites, and/or parasitoids) - Habitat management should provide for healthy, balanced, and diverse food and shelter for beneficial animals that provide natural pest control. Examples include: (1) providing habitat for native fish and aquatic beetle larvae that eat mosquitoes and native lady beetles that eat aphids attacking ornamental plants; (2) adding flowering cover crops or hedgerows to enhance natural enemies of crop pests; and (3) implementing Open Water Marsh Management in marshes to restore hydrology, native fauna, and control mosquito populations (Mader, et al., 2014; Mazzacano and Black, 2013; Rochlin, et al., 2012).

Introduce a natural enemy (predator, herbivore, parasite or parasitoid) - A native species that is a natural enemy of the pest can be purchased and released to supplement natural enemies present in the environment. This is typically done early in the season before native enemies have had a chance to increase in numbers. Unless the enemy selected is specific to the pest, the chance of successful control is limited in natural habitats because the enemy may not focus on the target pest, or stay in the local area (Olkowski, et al., 1991; Mader, et al., 2014).

In some cases, species that are not native to the ecosystem but which exclusively target the pest as a food source are released into the ecosystem to control the pest or weed. Examples include:

1. Introduction of Vidalia beetles (*Rodolia cardinalis*) from Australia to control cottony cushion scale (*Icerya purchasi*) on citrus crops in California.
2. Release of the tamarisk leaf beetle (*Diorhabda elongate)* to control salt cedar (*Tamarisk* spp.).
3. Release of the beetles, *Galerucella calmariensis, G. pusilla*, and *Nanophyes marmoratus* to control purple loosestrife (*Lythrum salicaria*).

Introduction of species that are not native to an ecosystem is not encouraged (and on most Federal lands is not allowed) except in rare circumstances. However, lawful and deliberate introduction of host specific biological control agents can be an effective, low risk, and economical tool to control a pest (Agricultural Research Service (ARS), 2016; Olkowski, et al., 1991; Wilson, et al., 2004).

Introduce a disease organism - A widely used, effective example of introducing a disease organism is the use of *Bacillus thuringiensis var. israelensis* (*Bti*), a commonly occurring soil bacterium, to kill mosquito larvae. *Bti* is naturally occurring and has been used against *Aedes*, *Anopheles* and *Culex* species of mosquitoes. It is effective against a variety of flies (Diptera); however, the greatest impact is on mosquitoes, black flies, and non-biting midges (Mazzacano and Black, 2013).

Control host populations - Populations of a pest species that rely on host organisms can be controlled by reducing the host population. An example is to reduce rodent populations to reduce ticks (Olkowski, et al., 1991).

Release of sterile individuals - Sterile insect techniques (SITs) have been effective for some pests. SIT is a species-specific method of insect control that relies on the release of large numbers of sterile individuals. Mating of released sterile males with native females leads to a decrease in the females' reproductive potential and ultimately, over a sufficient period of time and if enough sterile males are released, to local elimination or suppression of the pest. This technique has been used successfully to eliminate, and in some locations reduce, New World screwworm (*Cochliomyia hominivorax*) populations (Animal and Plant Health Inspection Service (APHIS), 2014). This tool is an evolving technology that may be used in the future for control of mosquitoes that vector disease (Alphey, et al., 2010).

Convergent lady beetle (*Hippodamia convergens*), a natural predator of aphids
(photo: Scott Bauer/USDA, ARS)

Screwworm showing mandibles
(photo: John Kucharski/USDA, ARS)

Table 10: Common pest treatments[20]

Pest	Cultural controls	Mechanical/Physical controls	Biological controls
Bats Bats provide important control of mosquitoes and other insects. Removal should focus on bats residing in man-made structures. CAUTION: Clearly identify the species before removal. Some bats are protected by law. Many states have laws or regulations that provide specific requirements and protections for bats. Do not use home remedies to control bats, including those that involve mixing chemicals.	• Use screens to exclude bats from outdoor openings in attics, chimneys and buildings. • Periodically inspect and maintain screens.	• Exclude from buildings using screens. • Secure screens, including on vents and eave openings.	No recommendations.
Fire Ants	• Clean up food and drink waste. • Seal trash.	• Maintain a barrier between soil and structures.	No recommendations.

[20] Sources: AFPMB, 2012; AFPMB, 2016; ARS, 2011; ARS, 2016; Benjamin, et al., 2002; CDC, 2016; Grissell, 2010; Hornbostel, et al., 2004; Mazzacano and Black, 2013; NRC, 2007; Nico, et al., 2016; Page and Burr, 1991; Rauchenberger, 1989; UC, 2016.

Pest	Cultural controls	Mechanical/Physical controls	Biological controls
Mosquitoes Most mosquito species are active during dawn or dusk.	• Remove/eliminate standing and/or stagnant water in buckets, planters, discarded tires, open tanks, and low-lying areas, such as road ruts. • Clean weekly, turn over, throw out, or fill with sand any containers and other items that hold water (e.g., empty plant saucers, tires, trash cans, shells, etc.). • Use screens on rain barrels and water cisterns. • Replace water in birdbaths and livestock troughs twice a week. • Fix outside water faucets that are dripping. • Clear rain gutters to allow rainwater to flow freely. • Check for trapped water in tarps used to cover equipment and arrange covers to drain water. • Pump out boat bilges. • For constructed sites (e.g., ponds) ONLY – Encourage predators by: (1) Managing vegetation in water to less than 20%, (2) constructing the pond with steep sides, and (3) maintaining a variety of depths of water with some deep pools and water flow. • For previously altered tidal areas ONLY - Use Open Marsh Water Management to restore natural draining and flooding of marsh. • Use approved repellents.	• Cover containers and other items that hold water (e.g., buckets, empty plant saucers, tires, trash cans, rain barrels, shells, etc.) that cannot be turned over, filled with sand or thrown out. • Repair cracks or gaps and cover open vents or pipes in septic systems with small wire mesh. • Maintain and repair screens for doors and windows.	• Use *Bacillus*-based products to control larval mosquitoes in standing waters. • Within their native range,[21] include mosquitofish (*Gambusia affinis*) in mosquito breeding areas to control for immature mosquitoes.

[21]Native Range: Atlantic and Gulf Slope drainages from southern New Jersey to Mexico; Mississippi River basin from central Indiana and Illinois south to Gulf. *Gambusia holbrooki* is native to Atlantic and Gulf Slope drainages as far west as southern Alabama. *G. affinis* occurs throughout rest of the range (Rauchenberger, 1989; Page and Burr, 1991). Also see: Nico, et al., 2016.

Pest	Cultural controls	Mechanical/Physical controls	Biological controls
Invasive Plants	• Visually inspect open spaces for invasive species, and remove when found. • Clean equipment and gear before moving to new habitats where seeds and plant parts could be spread by machinery. • Check clothing and remove invasive seed species before moving between sites. • Work first in the least infested sites moving into more infested areas.	• Dig up or mow repeatedly before or during growing season to prevent seeding. • Use prescribed fires, under the supervision of an ecologist with expertise in prescribed fires, to control, when appropriate. • Know growing season and use water management to limit growth of invasive plants.	• Use lawfully permitted biocontrol for heavy infestations (e.g., tamarisk leaf beetle, *Diorhabda elongate*, to control salt cedar).
Spiders Spiders provide important pest control through consuming insects. Removal should focus on poisonous species indoors, near entryways, and recreation areas.	• Wood, debris, compost and vegetation should be removed from around the house or building foundation. Store wood and compost away from buildings. • Use gloves and other clothing that covers skin while working in areas that may be infested to reduce exposure.	• Inspect and replace damaged weather stripping around doors, thresholds, and window sills. • Caulk cracks and crevices. • Screen doors, windows and crawl space vents. • Use glue traps.	No recommendations.

Pest	Cultural controls	Mechanical/Physical controls	Biological controls
Swarming bees Swarming is natural phenomena for honey bees. When their nest becomes too crowded, the colony produces new queens and males (drones) and the old queen leaves with some workers, forming a swarm until they find a new nesting site. Workers are usually not aggressive when swarming. Extreme caution should be used if Africanized honey bees[22] are suspected.	• Regularly clean hummingbird feeders.	• Trained personnel can collect swarming bees in a cardboard box or similar, and provide to local beekeepers. If trained personnel are not available, contact a local beekeeper to remove[23].	No recommendations.

[22] Africanized honey bees are a hybrid of European honey bees and the African race (*A. mellifera scutellata*). When disturbed they are more aggressive than European honey bees. As of 2011, they are reported in the south from Louisiana west to California (LA, AR, OK, TX, NM, UT, AZ, NV, CA), and in southern Florida in the U.S. (NRC, 2007; and ARS, 2011)

[23] Most state/local beekeeping associations have a webpage for beekeepers that remove swarms. Find the link for your state on the websites below, then navigate to the swarm removal page or other page with local beekeeper contact information:

- State Beekeeping Associations: http://www.honeytraveler.com/honey-by-country-region/united-states/united-states-beekeeping-associations/
- Eastern Apiculture Society: http://www.easternapiculture.org/links/beekeeping-organizations.html
- Heartland Apiculture Society: http://www.heartlandbees.org/links/

Pest	Cultural controls	Mechanical/Physical controls	Biological controls

Ticks	• Wear official uniform properly, including tucking pant legs into boots.
	• Change clothing after possible exposure to ticks. Segregate clothes that may have ticks and wash.
	• Check pets and/or assistance animals before entering house or structure.
	• Use approved repellents.
		• In areas with heavy human traffic:
		  ○ Manage vegetation to reduce tick-bearing mammals
		  ○ Cut grass and only plant low vegetation that is not attractive to tick-bearing mammals.
		• Repair crevices or gaps in structures.
		• Dispose of all empty bird and rodent nesting materials.
		• Remove dilapidated buildings.
			• Reduce deer activity in populated areas by placing protective fencing around deer-attracting plants and planting deer-attracting plants away from populated areas.
			• Entomopathogenic fungus (*Metarhizium anisopliae*) is under development as a control measure and may be approved for use in certain situations and areas.[24] Contact your local County Agricultural Commissioner.

Turf/Ornamental Pests	• Use a diversity of native plants to limit attractiveness to pests.	None recommended.	No recommendations.

[24] Entomopathogenic fungus is native and widespread in soil and leaf litter in North American forests, and virulent against ticks. Adult ticks are more susceptible than are larvae and nymphs (Benjamin, et al., 2002). The fungus can compromise the health, body condition, and reproductive output of ticks even when it does not kill them, and the effects of fungus might be enhanced when delivered in combination with low doses of the pesticide, permethrin (Hornbostel, et al., 2004). Field tests are underway to determine if applying the fungus to vertebrate hosts is a safe and effective method to reduce tick numbers. (Benjamin, et al., 2002). There was moderately strong effectiveness of *M. anisopliae* when delivered to the nesting materials inside experimentally deployed mouse nest boxes. Effects on non-target organisms can be minimized by targeting the fungus directly at hosts, rather than broadcasting it into the environment. (Hornbostel, et al., 2004)

Pest	Cultural controls	Mechanical/Physical controls	Biological controls

Wasps and Bees
Wasps that prey on insects can play an important role in controlling insect pests. Bees and some wasps are pollinators. Focus attention on wasps in high traffic areas.
CAUTION: Clearly identify species before removal to make sure they are not a protected bee species (e.g., certain bumble bees or yellow-faced bees).
	• Regularly inspect and clean eaves around doorways and windows, and high ceilings outdoors.
	• Avoid the area of bumble bee nests. If the vicinity of a bumble bee nest can be avoided, leaving them alone and waiting for them to die in the fall is the preferred management option.
		• Contact an experienced bee keeper to remove or relocate bee nests.
		• Have trained personnel remove wasp nests in the morning when they are less active.
		• Set up wasp traps.
		• ONLY near entryways, outdoor recreation areas (e.g., playgrounds, baseball fields), and other high use areas:
		  ○ Destroy old rodent burrows and similar cavities. Be cautious as bumble bee colonies are often located underground in abandoned rodent nests.
		  ○ Locate and remove nests and cavities such as hollow logs and landscape timber.
			No recommendations.

SECTION 3. E. MINIMIZING PESTICIDE IMPACTS

HIGHLIGHTS

- Pesticides are comprised of active ingredients and other ingredients
- Active ingredients are used to control the pest
- Other ingredients include solvents, anti-caking agents and preservatives and are sometimes called inert ingredients
- Selection of an appropriate pesticide, formulation, method and timing of application, and establishing buffers can all help to reduce impacts of pesticides to pollinators

The U.S. Environmental Protection Agency defines a pesticide as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (EPA, 2017a)." Pesticide use may be necessary when cultural, physical, mechanical, and biological methods have not brought the pest population below the action threshold. Pesticides are typically comprised of a combination of active ingredients, used to control the pest, and other ingredients, such as solvents, anti-caking agents, and preservatives. These other ingredients are sometimes referred to as inert ingredients (EPA, 2016b). Impacts to pollinators can be reduced by minimizing toxicity or reducing exposure of pollinators to the pesticide. Selection of an appropriate pesticide, formulation, method and timing of application, and establishing buffers can all help to reduce any impacts to pollinators.

Avoid applying pesticides when pollinators, such as *Osmia ribifloris*, a mason bee, are active (photo: Jack Dykinga/USDA, ARS)

3. E. 1. Minimizing toxicity

HIGHLIGHTS

- Select a pesticide that is specific to a pest
- Choose Minimum Risk Pesticides when effective
- Choose pesticides that have a low acute toxicity to bees
- Rinse pesticide tanks between use as the combination of pesticides can be more toxic than either alone
- Use liquid sprays or granules, rather than dusts, to avoid pesticides drifting to other plants
- Avoid systemic pesticides
- Avoid microencapsulated formulations
- Avoid applying pesticides when temperatures are low or dew is expected
- Select a pesticide that does not persist on vegetation
- Follow label instructions to protect sensitive species
- Use the lowest effective application rate

HELPFUL WEBSITES

- Minimum Risk Pesticide criteria: https://www.epa.gov/minimum-risk-pesticides/conditions-minimum-risk-pesticides
- Minimum Risk Active Ingredients: https://www.epa.gov/sites/production/files/2015-12/documents/minrisk-active-ingredients-tolerances-2015-12-15.pdf
- Minimum Risk Inert Ingredients: https://www.federalregister.gov/documents/2015/12/28/2015-32325/pesticides-revisions-to-minimum-risk-exemption
- EPA Pesticide Product Label System (pesticide labels): https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1

RELEVANT SECTION OF AFI

- AFI 32-1053, paragraph 4.5.3.: Follow pesticide label instructions

All pesticides are toxic, but toxicity will vary with the chemical, its formulation, half-life, and the organism exposed. The difference in toxicities to different organisms can be used to target specific pests or groups of pests, while conserving pollinators, other beneficial insects and natural enemies of the pest. Select a pesticide that is specific to the target organism to minimize impacts to pollinators and natural enemies of the pest. An example of a targeted pesticide is *Bti*, which affects mosquitoes, midges, and blackflies, but does not adversely impact mammals. Another example is hydramethylnon that targets fire ants and roaches, but does not adversely impact fish, mammals or birds (EPA, 1998; EPA, 2007a; EPA, 2016c; EPA, 2016e).

Pesticides can result in direct mortality of organisms (acute exposure[54]), or cause population reductions as a result of exposure over time (chronic exposure[55]) that reduces reproduction or interferes with feeding, reproductive behavior, learning, memory, or sheltering behavior. Pollinators can come into contact with a pesticide by being directly sprayed, contacting pesticide residue on a leaf, ingesting pesticides in water in areas where pesticides were sprayed, or ingesting pesticides taken up by plants into nectar or pollen (Hooven, et al., 2013; Vaughan, et al., 2014; Yu, 2008).

Choose a *Minimum Risk Pesticide* to reduce risk to pollinators, as well as other fish, wildlife, and humans when they are effective for the target pest (Table 11). *Minimum Risk Pesticides* must meet several conditions to be defined as such. Among the requirements to be considered a *Minimum Risk Pesticide* are that the active ingredients are included on the EPA's regulated list at 40 CFR 152.25(f) (1), and the inert ingredients are on a regulated list published at 80 FR 80653 (February 26, 2016). Active ingredients that are exempt from registration and considered to be *Minimum Risk Pesticides* are primarily plant oils. Many of the inert ingredients in *Minimum Risk Pesticides* are food products. Additional details can be found on EPA's website.

Many active ingredients in insecticides (other than those defined as *minimum risk pesticides*) are considered highly[56] or moderately[57] acutely toxic to bees (Table 12). EPA is responsible for pesticide registration, and requires toxicity testing as part of the pesticide registration review process. Until data that is more specific is available, the tests required for honey bees provide an indication of toxicity to native insect pollinators. As more testing is done, additional active ingredients may be considered acutely toxic to honey bees. Pesticides active ingredients that are acutely toxic to bees should only be used after other methods (cultural, physical/mechanical, and biological) and *minimum risk pesticides* have been evaluated and tried, as appropriate (Section 3.D). They should also be applied in a manner to minimize exposure to pollinators (Section 3.E. 2). When more toxic pesticides are required, choosing pesticide active ingredients with a lower toxicity to bees will reduce impact to pollinators.

The formulation of a pesticide product impacts its toxicity. Inert ingredients in a pesticide product can have impacts on non-target species, such as pollinators, even though they have no impact on the target pest. In general, toxicity testing conducted for product registration purposes is for technical grade active ingredients only, not formulations, which would include the inert ingredients. EPA acknowledges testing of product formulations is an area for further work (EPA 2017a; Hooven, et al, 2013).

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[54] Acute toxicity is measured as the (lethal) dose at which 50% of the test population dies, abbreviated as LD_{50}.

[55] Chronic toxicity is measured using the dose (effective concentration) at which 25 or 50% of the test population exhibits a sublethal effect, abbreviated as EC_{25} or EC_{50}, respectively.

[56] Pesticide active ingredients are defined as highly toxic if the LD_{50} is $\leq$ 2 micrograms (mcg)/bee.

[57] Pesticide active ingredients are defined as moderately toxic to pollinators if the honey bee acute contact LD_{50} (contact dose that will kill 50% of bees exposed in the laboratory) is > 2 mcg/bee and < 11 mcg/bee.

Pesticide combinations can be more toxic than either pesticide alone. Rinse pesticide tanks after each use to avoid cross-contamination of pesticides (Hooven, et al, 2013).

The form of the pesticide also impacts its toxicity to pollinators. Granular formulations are the least likely formulation to be picked up by pollinators. Care should be taken to apply these away from the nesting sites of soil-nesting pollinators, such as bees. Use liquid formulations, such as emusifiable concentrations, solutions and soluble powders, when granular formulations are not available. Liquid formulations can be problematic when directly sprayed on pollinators or when they remain as residues on vegetation, especially if pollinators are seeking water in areas where the pesticide was sprayed. The most likely formulations to be harmful to pollinators are: microencapsulated formulations, dusts, wettable powders, flowables, and systemic insecticides. These formulations should be avoided. Microencapsulated formulations can be harmful as they can be mistaken for pollen by bees, and brought back to the hive. Dusts, wettable powders, and flowables are also of high concern because they can easily be transported by wind to non-target areas, and they can stick to hairs on pollinators and be transported back to their nest. Systemic insecticides pose a problem as they are designed to be taken up into plant parts (leaves, pollen, nectar) that may provide food for pollinators, and remain active for a long time (e.g., years). Neonicotinoid pesticides (e.g., acetamid and imidacloprid) are examples of systemic pesticides (Delso, et al., 2015; Hooven, et al, 2013; Vaughan, et. al, 2015).

Another aspect of toxicity is residual toxicity, which is how long the pesticide remains toxic after application. Residual toxicity will be important if the pesticide selected is toxic to pollinators. In addition to the properties of the pesticide itself, soil properties (physical, chemical and microbial) and climatic conditions (moisture, temperature, and sunlight) will affect toxicity and how long the pesticide remains toxic. Select a pesticide with a shorter residual toxicity if choosing among several pesticides that are equally toxic to pollinators. Pesticides that remain on plant parts could be eaten by pollinators that feed on plant parts (such as butterfly larvae), or they may be taken back to the nest by pollinators (such as leafcutter bees), that use leaves as nesting materials. Pesticide residues typically persist twice as long at lower temperatures and when dew is present. Avoid applying pesticides in these conditions (Hooven, et al., 2013; Vaughan, et al., 2015).

Always follow pesticide label instructions. The label is the law and following the label is required by AFI 32-1053, paragraph 4.5.3. The label may have special instructions about where or when the pesticide can be applied. Following the label is important to protect sensitive species and habitats. Obeying label application rates is important because over-application is against the law and is more likely to harm pollinators, other wildlife, and humans. Under-application may lead to ineffective treatment and resistance. Use the lowest recommended, effective application rate.

Honey bees are used to test the toxicity of active ingredients (photo: Christopher Gezon/National Park Service)

Table 11: Minimum Risk Pesticides – active ingredients[58]

Castor oil	Cedarwood oil (China)
Cedarwood oil (Texas)	Cedarwood oil (Virginia)
Cinnamon	Cinnamon oil
2-Hydroxypropane-1,2,3- tricarboxylic acid	Citronella
Citronella oil	Cloves
Clove oil	Corn gluten meal
Corn oil	Cornmint
Cornmint oil	Cottonseed oil
Dried blood	4-Allyl-2-methoxyphenol
Garlic	Garlic oil
(2E)-3,7-Dimethylocta-2,6- dien-1-ol	Geranium oil
Lauryl sulfate	Lemongrass oil
Linseed oil	2-Hydroxybutanedioic acid
Peppermint	Peppermint oil
2-Phenylethyl propionate	Potassium (2E,4E)-hexa-2,4- dienoate
Putrescent whole egg solids	Rosemary
Rosemary oil	Sesame
Sesame oil	Sodium chloride
Sulfuric acid monododecyl ester, sodium salt	Soybean oil
Spearmint	Spearmint oil
Thyme	Thyme oil
White pepper	Zinc

[58] Source: EPA, 2015.

Table 12: Acute contact toxicity of pesticide active ingredients to honey bees[59]

Active ingredient[60]	Acute contact toxicity classification	Acute contact toxicity value (µg/bee)
Abamectin	High	0.54
Acephate	High	1.2
Acetamiprid	High to Moderate	1.69 - 8.09
Aldicarb	High	0.285
Allethrin	Moderate to Low	>3.4
Alpha-cypermethrin	High	0.023
Amitraz	Low	50->100
Arsenic acid	Low	>157
Azadirachtin	Low	37-61
Bensulide	Low	24
Beta Cyfluthrin	High	0.0120
Bifenazate	Moderate	7.8
Bifenthrin	High	0.0146
Boric Acid	Low	>362.58
Carbaryl	High	1.1
Carbofuran	High	0.036-0.16
Chlorethoxyfos	High	0.09
Chlorfenapyr	High	0.12
Chlorpyrifos	High	0.059
Chlorpyrifos methyl	High	0.383

[59] Sources: CA Department of Pesticide Regulation, 2008; EPA, 1995a; EPA, 1995b; EPA, 1996; EPA, 1997; EPA, 2000; EPA, 2004; EPA, 2006a; EPA, 2006b; EPA, 2006c; EPA, 2007b; EPA, 2007c; EPA, 2008; EPA, 2009; EPA, 2010; EPA, 2017b; EPA, 2017c; University of Hertfordshire, 2017; Zaluski, et al., 2015.

[60] See current *Standard list of pesticides available to DoD components and all federal agencies* (AFPMB) at: https://extranet.acq.osd.mil/eie/afpmb/cac/standardlists/DOD_PESTICIDES_LIST.pdf to find trade names for chemicals on this list used by DoD.

Active ingredient[60]	Acute contact toxicity classification	Acute contact toxicity value (µg/bee)
Clothianidin	High	0.0275
Cyantraniliprole	High	0.058
Cyfluthrin	High	0.037
Cypermethrin	High	0.023
Cyphenothrin	High	0.02-0.56
Deltamethrin	High	0.0015
Diazinon	High	0.052
Dichlorvos	High	0.495
Dicrotophos	High	0.076
Dimethoate	High	0.16
Dinotefuran	High	0.047
Diuron	Low	>100
D-trans-allethrin	Moderate	>3.4-3.9
Emamectin benzoate	High	0.0035
Endosulfan	Moderate to Low	>7.81
Esfenvalerate	High	0.0172
Ethoprop	Moderate	2.58-5.56
Etofenprox	High	0.0145
Fenazaquin	High	1.12
Fenitrothion	High	0.383
Fenoxycarb	Low	>100
Fenpropathrin	High	0.0015
Fipronil	High	0.0040
Fluazinam	Moderate	4.0
Fluvalinate	High	0.2
Fosthiazate	High	0.247
Gamma cyhalothrin	High	0.0061
Hydramethylnon	Low	67-68

Active ingredient[60]	Acute contact toxicity classification	Acute contact toxicity value (µg/bee)
Hydroprene	Low[61]	>1000
Imidacloprid	High	0.0439
Imiprothrin	High	0.52
Indoxacarb	High	0.1800
Lambda-Cyhalothrin	High	0.0380
Malathion	High	0.189
Metaflumizone	Low	>106
Methiocarb	High	0.375
Methomyl	High	0.068
Momfluorothrin	High	0.2
Naled	High	0.4800
Oxamyl	High	0.3100
Permethrin	High	0.024
Phenothrin	High	0.067
Phorate	High	0.32
Phosmet	High	1.06
Piperonyl butoxide	Low	>11
Pirimiphos-methyl	High	0.0666
Prallethrin	High	0.028
Profenofos	High	0.001
Propoxur	High	0.112
Pyrethrins	High	0.022
Pyridaben	High	0.024
Resmethrin	High	0.063
Sethoxydim	Moderate	10

[61] Bee larvae are affected at much lower doses (0.1 µg/bee).

Active ingredient[60]	Acute contact toxicity classification	Acute contact toxicity value (µg/bee)
Spinetoram (a mixture of spinetoram-J and spinetoram-L)	High	0.0240
Spinetoram (major component (4,5- dihydro)	High	0.024
Spinetoram (minor component (4-methyl)	High	0.0267
Spinosad	High	0.0029
Sulfoxaflor	High	0.13
Sumethrin (or d-phenothrin)	High	0.048 - 0.067
Tefluthrin	High	0.28
Tetrachlorvinphos	High	1.37
Tetramethrin	High	0.155
Thiamethoxam	High	0.0240
Tolfenpyrad	High	0.47
Zeta-cypermethrin	High	0.023

3. E. 2. Reducing exposure

HIGHLIGHTS

- Avoid applying pesticides in and near areas where pollinators are present
- Avoid applying pesticides in seasons when pollinators are present
- Apply pesticides late in the day or overnight when fewer pollinators are present
- Apply pesticides only when winds are low (≤ 7 mph) to avoid drift, but not during temperature inversions
- Reduce drift by purchasing and using equipment that minimizes drift
- Finer droplets are more likely to drift while larger droplets may expose pollinators to more pesticide
- Target the application to the pest
- Turn off sprayers when moving between application sites
- Place buffers between important pollinator foraging, reproduction, nesting and overwintering areas and treatment areas
- Avoid aerial application
- Notify base personnel, beekeepers, and neighbors of plans to spray when they may be impacted

RELEVANT SECTIONS OF AFI

- AFI 32-1074, paragraph 3.8.1.3.1: Aerial application of pesticides requires a spray map delineating spray and no-spray areas
- AFI 32-1074, paragraph 3.8.1.3.7.5: When applying pesticides aerially - bees must be protected, and local apiarists and apiary associations must be notified prior to aerial spraying

Consider the timing, method and location of pesticide applications to minimize exposure of non-targets, such as pollinators, to pesticides when developing IPMPs. This will require understanding something about the needs and activities of pollinators. Refer to Section 2.A. for information about food and habitat needs of pollinators.

Avoid applying pesticides in and near areas where pollinators are present. An easy first step in determining if pollinators are present is to look at the area to be treated and see if there are flowering plants. If so, it is likely pollinators are present. Some pollinators, such as butterflies and moths, may be present even in season when there are no flowering plants because they use other plant parts (e.g., leaves, seed pods) during the immature or larval stage. If there are species of concern present, avoid treating plants they use during the season when the immatures are likely to be present (Hooven, et al, 2013; USDA and DOI, 2015; Vaughan, et. al, 2015).

When it is not possible to avoid treating areas used by pollinators, pesticide exposure can be minimized by applying pesticides at times when pollinators are not present. Many pollinators

forage on flowers during the day, so treating an area in the late evening or overnight, with a pesticide that has a short residual time, will minimize exposure. For example, applying a pesticide with a residual time of four hours in the late evening or overnight is far less likely to impact pollinators that are found in the area of application only during the day. See Section 3.E.1. for a discussion of residual toxicity. Some pollinators may be harmed by nighttime application of pesticide. Examples of these would be: (1) *Normia* bees, which rest in crop fields overnight, (2) moths, which actively forage at night; and (3) immature stages of butterflies, which do not leave their host plants overnight. Before applying pesticides at night, check to determine if there are pollinators, especially any species of concern, likely to be found in the area to be treated at night (Hooven, et al., 2013; Natural Resource Council Canada, 1981; Vaughan, et al., 2015; USDA and DOI, 2015).

Weather conditions are an important consideration in making sure that the pesticide reaches only the target pest. Avoid applying pesticides when it is too windy (winds greater than seven miles per hour) because pesticides can be blown far away from the target site. Avoid applying pesticides during temperature inversions (when warmer air traps cool air below, e.g., during early morning fog) because in these conditions pesticides can linger in the air and drift long distances (Hooven, et al., 2013; Vaughan, et al., 2015).

Pesticide drift, whether dust or droplets, should be minimized to avoid impacts to pollinators and other non-targets. The equipment used to apply a pesticide can impact how much drift will occur. Purchase and use equipment that helps reduce drift. Drift reduction technologies on application equipment is rated by EPA (2016a), as follows:

- One star -- 25-50 % reduction
- Two stars -- 51-75 % reduction
- Three stars -- 76-90 % reduction
- Four stars -- More than 90 % reduction

Additional actions recommended by EPA (2016a) to reduce drift are:

1. Only apply the pesticide directly to the treatment area.
2. Apply the pesticide in a manner so that the product does not enter storm drains, drainage ditches, gutters, or surface waters.
3. Apply pesticides during calm weather conditions, when rain is not predicted for the next 24 hours, to ensure that wind or rain does not blow or wash pesticide off the treatment area.
4. Rinse application equipment over the treated area to avoid runoff to water bodies or drainage systems.
5. Sweep any granular product accidentally applied to a driveway, sidewalk, or other hard impervious surface, back onto the treated area to prevent runoff to water bodies or drainage systems.
6. When watering treated areas, refer to the watering-in instructions on the pesticide label, and ensure the treated area is not watered to the point of runoff.

Droplet size is important whether it is pesticides are applied by ground or air. Finer droplets have a great probability of drifting into non-target buffer zones where pollinators may be present. Larger droplets can expose pollinators to greater amounts of pesticide. Within the range of

droplet sizes allowed by the label, select a droplet size based on the pesticide, its toxicity to local pollinators, and method of application (aerial or ground). When using backpack sprayers, drift can be reduced by setting the nozzles just above plant height and at the lowest pressures (15–30 pounds per square inch) to increase spray droplet size (Vaughan, et al., 2015; USDA and DOI, 2015).

Targeting the application is extremely important. The goal is to treat the pest and not harm pollinators and other non-target organisms. Applying the pesticide in too broad an area will waste chemical and can make the pest problem worse. The broadcast use of herbicide favors reemergence of invasive nonnative species. Examples of targeted application include: (1) treating small infestations of invasive plants using a hand or backpack sprayer to treat leaves; and (2) manually cutting invasive plants, then painting the stumps with an herbicide. These methods allow greater control over where the pesticide is applied than spraying the entire area using a truck. Always turn off sprayers when moving between application sites. When targeting is not possible, maintain buffers between important pollinator foraging, reproduction, nesting, and overwintering areas and the treatment area to protect pollinators from drift. Suggested buffers are 25 to 100 feet for ground application (USDA and DOI, 2015).

Avoid aerial application whenever possible. If aerial application is necessary, a 600-foot buffer is generally recommended. However, a half mile buffer or greater might be needed depending on application measures and product to protect sensitive species. Remember AFI32-1074, *Aerial Application of Pesticides*, paragraph 3.8.1.3.1 requires a spray map with well-delineated spray and no-spray area(s). Notify base personnel, beekeepers, and neighbors who may be impacted by spraying. Protection of bees during aerial application and notification of local beekeepers and apiary associations is required by AFI32-1074, paragraph 3.8.1.3.7.5 to give beekeepers an opportunity to protect their hives (Hooven, et al, 2013; Hopwood, et al., 2015; USDA and DOI, 2015; Vaughan, et al., 2015).

Always follow pesticide label instructions. The label is the law and following the label is required by AFI 32-1053, paragraph 4.5.3. There may be special instructions about where or when the pesticide can be applied on the pesticide label. Following the label is important to protect sensitive species and habitats. Obeying label application rates is important because over-application is against the law and is more likely to harm pollinators, other wildlife, and humans. Under-application may lead to ineffective treatment and resistance. Use the lowest recommended, effective application rate. Product labels can be found on the EPA Pesticide Product Label System website.

Targeted application of herbicide to Brazilian peppertree (photo: Steve Hillebrand/USFWS)

SECTION 4: PROMOTING POLLINATOR CONSERVATION THROUGH EDUCATION AND OUTREACH

This section will help Air Force Natural Resource and Pest Management Program personnel educate members of the Air Force community whose support is needed to implement pollinator conservation measures. It begins with a quick overview of the outreach planning process. Section 4.A discusses target audiences, goals and messages and provides example goals and messages for reaching out to some important target audiences. Section 4.B provides a brief discussion of implementation tools, resources (beyond this Reference Guide), and methods of evaluation.

Successful implementation of the *U.S. Air Force Pollinator Conservation Strategy* will depend on Natural Resource and Pest Management Program personnel integrating pollinator conservation into INRMP and IPMP development and implementation. These personnel will need to educate the Air Force community of base workers, residents, and visitors, to gain support for management changes. They can identify and take advantage of educational opportunities to teach community members how pollinator conservation supports the Air Force mission and how they can help conserve pollinators. Engaging partners and the public, especially neighboring communities, in pollinator conservation can increase the impact of actions on the installation. Neighboring communities can provide habitat corridors to connect pollinator populations. This could significantly increase effective pollinator population size and resiliency. National Public Lands Day (NPLD) and Earth Day events provide excellent opportunities to educate visitors about how they can support pollinator conservation at home. An outreach strategy is recommended to ensure educational efforts have the desired results.

A successful outreach program should:

- Identify a target audience(s)
- Describe the goal(s) for the target audience
- Develop messages for the target audience
- Develop an implementation strategy
- Evaluate success of the outreach activities

The first step in developing a successful outreach program is to identify a target audience or multiple target audiences (i.e., the group or groups you are trying to educate or engage). The target audience will be a group or individual whose help or cooperation is needed to implement

pollinator conservation measures. The group could be internal to Air Force (e.g., program leadership, contracting officers) or external (e.g., installation visitors).

The second step is identifying a goal(s). The goal(s) is/are what you want the target audience to do or understand because of education or outreach efforts. For example, one goal for construction personnel might be to limit soil disturbance and areas where heavy equipment travels and operates.

Next, a message needs to be crafted for the particular target audience. Each target audience will have different interests and priorities. The message should explain why this is important to, and resonate with, the specific target audience. Sometimes this is framed in terms of "what's in it for me (the target audience)?" For example, one message for construction personnel might be that reducing damage to vegetation will mean a smaller area that needs to be re-planted, and therefore reduced costs.

Once the target audiences, goals, and messages are identified, an implementation strategy needs to be developed. The implementation strategy should include:

1. A time-line
2. The communication products (e.g., presentations, fact sheets, briefing papers, glossy brochures, signage, displays, training, etc.) appropriate for the target audience
3. Who will develop the communication products
4. A distribution plan for the communication products (if appropriate)
5. Funding sources, if needed (e.g., for printing or constructing a kiosk)
6. If relevant,
    a. A list of people that need to be notified about planned outreach/education efforts
    b. A list of groups that could become partners in the outreach/education efforts

Construction crews can benefit pollinators by minimizing ground disturbance (photo: AZ Air National Guard)

Finally, determine how to evaluate the success of the outreach program and adjust the program based on the evaluation. Are the outcomes consistent with the goals? If not, does the target audience understand the message? Are the right products being used to deliver the message? If not, then the implementation strategy needs to be adjusted – perhaps by changing the message or the delivery mechanism – to be more effective.

SECTION 4. A. TARGET AUDIENCES, GOALS AND MESSAGES

4. A. 1. Identifying target audiences

HIGHLIGHTS

- Successful implementation of some pollinator conservation measures will require cooperation of installation personnel (e.g., civil engineering, operations and recreation program leadership, contracting officers, pesticide applicators, outdoor recreation personnel, landscaping crews, etc.) outside the Natural Resource and Pest Management Programs
- Informal or formal outreach and education of these target audiences will be needed to obtain their cooperation and support for changes in installation land management

Incorporating pollinator conservation measures within INRMPs and IPMPs is an important step in making pollinator conservation a priority, obtaining project funding, and in some cases complying with ESA and MBTA. Successful implementation of some measures may require cooperation from personnel outside the Natural Resource and/or Pest Management Programs that are part of the installation community. For example, landscapers, fire specialists, leaseholders or contractors may be responsible for implementing the conservation measures. Leadership support may be required to obtain approval or funding for some actions. These groups (called target audiences) will need to understand why new or modified procedures are being implemented and how they support the mission. Some informal or formal outreach and education will be necessary to obtain their cooperation and support.

The target audiences, whose support is critical in implementing pollinator conservation measures, may include:

- Air Force leadership (especially in civil engineering, operations and outdoor recreation)
- Contracting officers
- Pesticide applicators
- Outdoor recreation personnel
- Landscaping crews
- Fire specialists
- Maintenance personnel

- Agricultural lease holders
- Construction personnel
- Golf course managers
- Installation residents and visitors

There may be other target audiences depending on activities on, or adjacent to the installation.

More targeted outreach may be required when public support is needed to conserve rare pollinators located on and off installations, or provide corridors for pollinator movement between lands under different ownership. Alternatively, it may be beneficial to educate neighbors and visitors about visible changes in installation land management practices to conserve pollinators. The public may perceive less frequent mowing, a wider variety of native species being used in landscaping, and a reduction of broad-spectrum insecticides used as a lack of management, rather than a well-thought out management plan.

4. A. 2. Goals and messages for selected target audiences

HIGHLIGHTS

- Outreach goals and messages should be tailored to each specific target audience.
- Messages often will include the following information:
  - Actions required by law, regulation or policy.
  - How conserving pollinators will support the military mission, save money, benefit the military community, and help comply with other natural resource policies or achieve other natural resource goals.
  - Areas where help is needed implementing pollinator conservation measures
  - Specific actions that will support pollinator conservation, and if timing (time of day or season) is important.

HELPFUL WEBSITES

- DoD Natural Resources Program Pollinators webpage: (see especially fact sheets) http://www.denix.osd.mil/nr/priorities/pollinators/
- DoD Pollinator Initiative Resources webpage: http://www.dodpollinators.org/Resources.html

Incorporating pollinator conservation measures in INRMPs and IPMPs is an important step; however, full success will depend on implementation of these plans. In many cases, action will be required of personnel outside the natural resource or pest management program. These actions will form the basis of the goals identified for each target audience. Identifying specific goals will enable you to tailor the messages for each target audience and make it easier to evaluate success.

Pollinator conservation messages for military target audiences often will including the following information:

1. Actions required by law, regulation or policy.
2. How conserving pollinators will support the military mission, save money, benefit the military community, and help comply with other natural resource policies or achieve other natural resource goals.
3. Areas where help is needed implementing pollinator conservation measures
4. Specific actions that will support pollinator conservation, and if timing (time of day or season) is important.

The following sections provide examples of potential goals and messages for some internal target audiences. These will need to be adapted to the specific situation at the installation. It may be helpful to look at the DoD Natural Resources Program Pollinators webpage, especially the fact sheets, and the DoD Pollinator Initiative Resources webpage for other potential messages.

TARGET AUDIENCE 1: AIR FORCE LEADERSHIP (ESPECIALLY IN CIVIL ENGINEERING, OPERATIONS AND OUTDOOR RECREATION)

Goal: Approve and support pollinator conservation measures within installation INRMP and IPMP.

Potential Messages:

- The Under Secretary of Defense Memo (see Introduction, *Why is pollinator conservation important to the Air Force*) directed use of current best management practices to protect pollinators and their habitats, including "when possible and to the extent practicable, use native landscaping and minimize the use of pesticides in sensitive habitats …"
- Landscaping with native vegetation is supported by Air Force policy (AFI 32-7064, Chapter 12.3).
- Reduced pesticide (e.g., insecticide, herbicide and fungicides) use and targeted pesticide application will reduce costs, increase effectiveness, and encourage native predators and parasites that will help control pests. This is part of IPM, which is Air Force policy (AFI 32-1053).
- Diverse natural habitats are important for realistic overflights and training missions, buffers for local communities, and long-term sustainability of our natural heritage. Conservation of pollinators promotes healthy diverse habitats because of their essential role in plant reproduction.
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions to future operations and training that could occur if the species becomes federally listed.
- Landscaping with native vegetation reduces water usage, maintenance costs, and pest problems.

- Healthy, diverse native plant communities require less active management and are more resilient to human and naturally occurring stressors.
- Landscaping with native vegetation will give the installation a local character so personnel realize they are in (fill in the state or habitat type where the installation is located, e.g., the Sonoran Desert).
- Reduced mowing will reduce costs and our carbon footprint.
- Conserving pollinators can enhance the morale and welfare of Air Force personnel and their families by providing a variety of outdoor recreation opportunities.
- Pollinator conservation offers opportunities for partnerships, community-based activities, youth program community service support, and outdoor education.

Diverse natural habitats are important for realistic overflights (photos: Tech. Sgt. Larry E. Reid, Jr. /U.S. Air Force)

TARGET AUDIENCE 2: CONTRACTING OFFICERS

Goal: Work with the Natural Resource Management and Pest Management Programs to include in contracts measures to benefit pollinators.

Potential Messages:

- The Under Secretary of Defense Memo (see Introduction, *Why is pollinator conservation important to the Air Force*) directed use of current best management practices to protect pollinators and their habitats, including "when possible and to the extent practicable, use native landscaping and minimize the use of pesticides in sensitive habitats …"
- Landscaping with native vegetation is supported by Air Force policy (AFI 32-7064, Chapter 12.3).
- Reduced pesticide (e.g., insecticide, herbicide, fungicide) use and targeted pesticide application will reduce costs, increase effectiveness, and encourage native predators and parasites that will help control pests. This is part of IPM, which is Air Force policy (AFI 32-1053).

- Air Force policy requires evaluation of opportunities to minimize pesticide use while maintaining mission support requirements (AFI 32-1053, paragraph 4.5.5).
- Air Force policy requires that land use rules for agricultural outleases support natural resource goals and objectives and not degrade natural ecological integrity (AFI 32-7064, Chapter 10).
- Contractors are required to use IPM identified in the IPMP (AFI 32-1053, paragraph 4.7).
- Air Force policy requires measures to prevent the introduction and spread of invasive species be included in cropland and grazing outgrant agreements (AFI 32-7064, Chapter 14.4).
- Air Force policy requires GEM Plans to "minimize or eliminate potential negative impacts to the environment and the surrounding community" (AFI 32-7064, Chapter 12.4).
- Diverse natural habitats are important for realistic overflights and training missions, buffers for local communities, and long-term sustainability of our natural heritage. Conservation of pollinators promotes healthy diverse habitats because of their essential role in plant reproduction.
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions to future operations and training that could occur if the species becomes federally listed.
- Healthy, diverse native plant communities require less active management and are more resilient to human and naturally occurring stressors.
- Landscaping with native vegetation reduces water usage, maintenance costs, and pest problems.
- Reduced mowing will reduce costs and our carbon footprint
- Conserving pollinators can enhance the morale and welfare of Air Force personnel and their families by providing a variety of outdoor recreation opportunities.

Diverse natural habitats are important for realistic training exercises (photo: Staff Sgt. Edward Eagerton/U.S. Air National Guard)

TARGET AUDIENCE 3: PESTICIDE APPLICATORS (INCLUDING CONTRACTORS)

Goals:

1. Use monitoring and establish action thresholds to determine when to treat a pest problem.
2. In outdoor areas where pollinator conservation is a goal, eliminate and reduce pesticide use by only treating when the action threshold is met and using cultural, physical/mechanical, and biological methods to control pests.
3. When pesticides are necessary to achieve management goals in outdoor areas where pollinator conservation is a goal, have applicators select and use them in a manner that reduces toxicity and exposure of pollinators.

Potential messages:

- Air Force policy requires pest management operations to be based on appropriate surveillance data (AFI 32-1053, paragraph 3).
- Air Force policy requires evaluation of opportunities to minimize pesticide use while maintaining mission support requirements (AFI 32-1053, paragraph 4.5.5).
- Contractors are required to use IPM identified in the IPMP (AFI 32-1053, paragraph 4.7).
- Follow Air Force policy (AFI 32-1053) and use IPM.
- Following pesticide label instructions is required by the law and Air Force policy (AFI 32-1053, paragraph 4.5.3) and helps protect sensitive species and habitats.
- Monitoring to determine when to treat a pest problem reduces costs and time and helps prevent pest's resistance to pesticides.
- Reducing and targeting pesticide use will reduce costs for chemicals, promote healthy ecosystems where native predators and parasites will help control pests and benefit pollinators.
- Use cultural, physical/mechanical, and biological methods to control pests when effective.
- When pesticides (e.g., insecticide, herbicide, fungicide) are necessary to achieve management goals protect pollinators by:
    - Selecting pesticides and formulations with low toxicity to pollinators and low persistence in the environment.
    - Using the lowest effective application rate.
    - Targeting pesticide application by selecting pesticides specific to the pest problem and applying them directly to the pest (e.g., paint stumps or spray leaves directly, rather than using trucks or planes to apply pesticide).
    - Minimizing exposure of pollinators to pesticides through timing (e.g., late in the day or overnight, in low winds) and application method.
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions on pesticide use that could occur if the species becomes federally listed.
- Diverse natural habitats are important for realistic overflights and training missions, buffers for local communities, and long-term sustainability of our natural heritage.
- Conservation of pollinators promotes healthy diverse habitats because of their essential role in plant reproduction.

- Pollinators are beneficial. They are responsible for helping over 75% of native flowering plants reproduce and nearly as many crops including berries, peaches, apples, pumpkins, and chocolate. They and the plants they require can be harmed by some pesticides (e.g., insecticides, herbicides, fungicides). Help protect them by reducing and targeting pesticide use.

TARGET AUDIENCE 4: OUTDOOR RECREATION PERSONNEL

Goals:

1. When installing or maintaining landscaping in outdoor recreation areas include a variety of native flowering plants and eliminate invasive plants.
2. Reduce the use of pesticides using cultural, physical/mechanical, and biological controls to help reduce pest problems.
3. When pesticides are needed to meet management goals, limit their use to the target pest, while avoiding use in locations or at times when pollinators are present.
4. Leave some habitat around recreation areas for pollinator nesting and overwintering.
5. Include pollinator conservation themes in educational programs and activities.
6. Encourage community service projects with a pollinator conservation theme.
7. Understand, appreciate and share information about the great diversity of native pollinators and their importance to plant reproduction in native ecosystems and agriculture.

Enjoying nature (photo: Brett Billings/USFWS)

Potential Messages:

- Use of native vegetation is supported by Air Force policy (AFI 32-7064, Chapter 12.3) and the Under Secretary of Defense Memo (see Introduction, *Why is pollinator conservation important to the Air Force*).
- Reducing and targeting pesticide (e.g., insecticides, herbicides, fungicides) use is part of IPM, which is Air Force policy (AFI 32-1053).
- Conserving pollinators provides opportunities for enjoying watching nature and nature photography.
- Insect pollinators are great subjects for a variety of educational programs (e.g., nature, natural community interactions, gardening, and nutrition) and can be found in urban and rural areas.
- Most native bees are solitary so they do not sting to defend their nest as do honey bees and social wasps.
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions that could occur if the species becomes federally listed.
- Pollinators are responsible for helping over 75% of native flowering plants reproduce and nearly as many crops including berries, peaches, apples, pumpkins, and chocolate.
- There are many opportunities for youth and citizen science projects focused on pollinators, such as bumble bees and butterflies.
- Native vegetation gives the installation a local character and may reduce water usage, maintenance costs, and pest problems.
- Reducing and targeting pesticide application will reduce costs (from pesticide that does not reach the target), increase effectiveness, and allow native predators to control pests naturally.
- Eliminate breeding sites for mosquitoes by eliminating standing water. Change water in bird baths once or twice weekly (to prevent development of larval mosquitoes) and turn over or cover unused containers to eliminate standing water.
- There are easy things you can do within and around recreation areas to help provide pollinator habitat:
    - Leave areas of open soil that naturally occur around field edges for native bee and other pollinators nesting sites.
    - When mulching, use less than an inch of pine fines, cedar mulch, or compost to allow access to soil by ground-nesting bees. Do not use plastic mulch or landscape cloth, which bees cannot tunnel through, or hardwood mulch, that can make the soil acidic and rob plants of nutrients because of the high cellulose content.
    - When cleaning-up, consider the following if in areas where it is safe to do so:
        - Leave potential pollinator nesting sites intact (snags, dead tree trunks, open patches of soil) especially in the far reaches of recreation areas.
        - Wait until spring to deadhead plants and remove dry stems with hollow or soft, spongy centers in planting beds as they provide pollinator nesting sites.
        - Do not cut landscaping plants to the ground (leave part of the stems) for pollinator nesting.

TARGET AUDIENCE 5: LANDSCAPING CREWS (INCLUDING CONTRACTORS)

Goals:

1. Choose a variety native flowering plants when replacing existing landscaping.
2. Eliminate or control invasive plants.
3. Leave potential habitat for pollinator nesting and wintering intact in landscaped areas.
4. Manage mowing to maximize availability of flowering plants.
5. Eliminate or reduce use of pesticides by using cultural, physical/mechanical, and biological controls to help reduce pest problems.
6. When pesticides are needed to meet management goals, target their use to the pest and use in locations or at times when pollinators are not present.

Potential Messages:

- Landscaping with native vegetation is supported by Air Force policy (AFI 32-7064, Chapter 12.3) and the Under Secretary of Defense Memo (see Introduction, *Why is pollinator conservation important to the Air Force*).
- Reducing and targeting pesticide use is part of IPM, which is Air Force policy (AFI 32-1053).
- Contractors are required to use IPM identified in the IPMP (AFI 32-1053, paragraph 4.7).
- Air Force policy requires pest management to be based on appropriate surveillance data (AFI 32-1053, paragraph 3).
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions that could occur if the species becomes federally listed.
- Pollinators are beneficial. They are responsible for helping over 75% of native flowering plants reproduce.
- Landscaping with native vegetation will reduce water usage, maintenance costs, and pest problems.
- Use cultural, physical/mechanical, and biological controls to help reduce pest problems.
- Pollinators and the plants they require can be harmed by some pesticides (e.g., insecticides, herbicides, fungicides). Help protect them by:
    - Using the lowest effective application rate.
    - Minimizing pollinator exposure to pesticides through timing (e.g., late in the day or overnight, in low winds) and application method.
    - Following pesticide label instructions as required by the law and Air Force policy (AFI 32-1053, paragraph 4.5.3).
- Reducing and targeting pesticide application will reduce costs (from pesticide that does not reach the target), increase effectiveness, and allow native predators to control pests naturally.

- There are easy things you can do to help provide habitat for pollinators:
    - When mulching, use less than an inch of pine fines, cedar mulch, or compost to allow access to soil by ground-nesting bees. Do not use plastic mulch or landscape cloth, which bees cannot tunnel through, or hardwood mulch, that can make the soil acidic and rob plants of nutrients because of the high cellulose content.
    - When cleaning-up:
        - Leave potential pollinator nesting sites intact (snags, dead tree trunks, open patches of soil) especially around or between planting beds.
        - Wait until spring to deadhead plants and remove dry stems with hollow or soft, spongy centers as these provide pollinator nesting sites.
        - Do not cut plants to the ground. Leave part of the stems for pollinator nesting.
- Pollinators need flowering plants. You can help them by reducing the areas mowed and mowing after flowering plants have set seed using a high blade height (2.5 inches for lawns and 10-16 inches, for other areas). This will also reduce costs and our carbon footprint.

Landscapers can help pollinators by waiting until spring to deadhead plants to provide potential nesting sites for bees and seeds for birds (photo: Dolores Savignano/USFWS)

Goals:

1. Include pollinators on the sensitive resources checklist and work with a biologist knowledgeable about pollinators when developing the prescribed fire plan.
2. Adjust timing, frequency, patch size and intensity of burn, as needed to protect special status species.
3. Use prescribed fire to promote habitat heterogeneity and flowering plant diversity and abundance.
4. Adjust patch size (relative to the surrounding habitat) and intensity of burn to create a mosaic pattern of burned and unburned habitat to allow pollinators to recolonize from surrounding areas.
5. Allow enough time between prescribed fires so that pollinators have time to recover or reestablish populations. In general, do not burn more than 30% of a site per year.
6. Avoid high intensity fires unless needed to meet habitat management goals.

Prescribed fires that promote habitat heterogeneity and diverse, abundant flowering plants can improve pollinator habitat (photo: Ryan Hagerty/USFWS)

Potential Messages:

- Air Force policy (AFI 32-7064, Chapter 13.3.8) requires a checklist of sensitive natural resources be included in Wildland Fire Management Plans. Include pollinators on the sensitive resources checklist and work with a biologist knowledgeable about pollinators when developing the prescribed fire plan to make sure a prescribed fire does not harm pollinators.
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions that could occur if the species becomes federally listed.
- Habitat diversity is important to providing a realistic training and testing environment. Pollinators are critical to maintaining diverse and healthy ecosystems because they help over 75% of native flowering plants reproduce.
- Fire can be a valuable management tool for creating and maintaining pollinator habitat including promoting habitat heterogeneity and increasing flowering plants. However, many pollinators cannot withstand fire and those with limited distribution may not be able to recolonize after a fire.
- Adjustments to the burn plan (e.g., seasonality, frequency, intensity, patch size) may be necessary to prevent the permanent loss of local pollinator species, and will likely be required for special status species.
- Burning too much of the habitat, burning it too frequently or too intensely will likely reduce or eliminate pollinator populations. The following actions will help pollinators:
    - Keep the burn size small enough relative to the surrounding habitat so that pollinators are able to recolonize.
    - In general, do not burn more than 30% of a site per year.
    - Allow enough time between prescribed fires so that pollinators have time to recover or reestablish populations.
    - Conduct burns when fuel conditions promote a mosaic pattern of burned and unburned habitat.
    - Avoid high intensity fires unless needed to meet habitat management goals.
    - Consider pollinators when determining time of year to burn.

TARGET AUDIENCE 7: MAINTENANCE PERSONNEL (INCLUDING CONTRACTORS)

Goal: Do not use pesticides in outdoor areas without explicit permission from the Pest Management Specialist.

Potential Messages:

- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions that could occur if the species becomes federally listed.
- We are trying to protect sensitive species in (specify the area, e.g., the FamCamp area). Check with the Pest Management Specialist before using pesticides in this area.

Goals:

1. Leaseholder will use IPM to control pests. Do not use seeds treated with pesticides.
2. Leaseholders will control the spread of invasive plants.
3. Leaseholders that are crop producers will take measures, especially around field edges or between fields to maximize native flowering plants and pollinator habitat features for nesting and overwintering.
4. Haying leaseholders (in areas with flowering plants) will take measures to: (1) provide native flowering plants and bunch grasses for pollinators within their fields, and (2) hay in a manner to provide an escape path and refugia for pollinators.
5. Grazing leaseholders will protect pollinator habitat by using rotational grazing, maintaining fencing, and locating high use areas away from known concentrations of bee nests and pollinator host plants.
6. Grazing leaseholders will provide native plants beneficial to pollinators when they re-seed.
7. Beekeepers will locate honey bee hives two to five miles from sensitive pollinator or plant resources and flowering invasive plants.

Potential Messages:

All agricultural lease holders

- Leaseholders are required to obtain Air Force permission prior to use of pesticides (AFI 32-7064, Chapter 6).
- Use IPM, including monitoring to determine when to apply pesticides, is required by Air Force policy (AFI 32-1053).
- Pollinators are beneficial. They contribute over $29 billion to the U.S. economy through services to crops. Nearly 75% of crops rely on animal pollinators, including strawberries, pumpkins, tomatoes, blueberries, apples.
- There have been declines in pollinators, including certain bumble bees, butterflies, hummingbirds, bats, and honey bees. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions that could occur if the species were federally listed.
- Reducing and targeting pesticide application will reduce costs (from pesticide that does not reach the target), increase effectiveness, and promote healthy ecosystems where native predators and parasites will help control pests.
- Pollinators and the plants they require can be harmed by some pesticides (e.g., insecticides, herbicides, fungicides). Help protect pollinators by reducing and targeting pesticide use.
- Beneficial plants (e.g., crops) will do better if invasives plants are kept under control.

Animals pollinate many crops like berries (photo: Scott Bauer/USDA, ARS)

Crop producers

- Increased native pollinator populations will reduce the need to rent or keep honey bee hives for crop pollination.
- Help pollinators by:
    - Using IPM and controlling invasive species.
    - Leaving or adding native flowering plants and pollinator habitat features (snags, bunch grasses, etc.) around the edges or between fields.
    - Reducing soil disturbance, especially around/between fields, to provide pollinator nesting sites.
    - Staggering when flowering crops are planted to have continuous blooms throughout the season to provide floral nectar to pollinators.
    - Delaying plowing plants under until after flowers bloom.

Haying lease holders (in areas with flowering plants)

- Help pollinators by:
    - Using IPM and controlling invasive species.
    - Mowing from one end of the field to the other to allow pollinators to escape.
    - Haying only once annually after flowers have bloomed giving pollinators the opportunity to feed on floral nectar.
    - Limiting haying to 50 to 70% of the local area with flowering plants to provide refugia for pollinators.
    - Rotating which areas are hayed to allow pollinators to reestablish.
    - Re-seeding or inter-seeding with native flowering plants and bunch grasses to support pollinator populations.

Grazing lease holders

- Grazing can benefit pollinators by maintaining or producing a mix of open and shrubby areas and helping to control invasive plants.
- Heavy grazing can harm pollinators by reducing flowering plant abundance and diversity, compacting soils, and destroying pollinator nests found in soil.
- Ill-timed grazing can dramatically reduce flowering plants, reducing nectar and pollen available to pollinators, and kill larval pollinators feeding on the plants being consumed.
- Help pollinators by:
    - Using IPM and controlling invasive species.
    - Using rotational grazing to: rest areas to reduce soil compaction, allow plants to flower and set seed, provide refugia for pollinators, and promote habitat for butterfly egg and larvae development.
    - Maintaining fencing to rest areas and protect important pollinator habitat.
    - Locating high use areas away from known concentrations of bee nests and pollinator host plants (plants used by butterfy and moth caterpillars).
    - Re-seeding or inter-seeding with native plants beneficial to pollinators.

Beekeepers:

- Locating hives two to five miles from sensitive pollinator or plant resources and flowering invasive plants will minimize competition between native bees and honey bees and help prevent honey bees from pollinating invasive plants.

Golf players may enjoy seeing pollinators, such as this Eastern tiger swallowtail, *Papilio glaucus*, while golfing
(photo: Ryan Hagerty/USFWS)

TARGET AUDIENCE 9: GOLF COURSE MANAGERS

Goal: Include management prescriptions favorable to pollinators in the GEM Plan and implement them. Examples include:

1. Reduce mowing in out-of-play areas.
2. Plant additional native flowering plants and bunch grasses in out-of-play areas and as buffers around water hazards.
3. Manage habitat to provide nesting and overwintering sites (snags, stems with hollow or soft, spongy centers, open soil, butterfly host plants) for pollinators.
4. Use monitoring and establish action thresholds to determine when to treat a pest problem.
5. Reduce and modify pesticide use using IPM. Avoid use of methyl isothiocyanate.
6. Remove invasive plants.

Potential Messages:

- Use of IPM, including monitoring to determine when to apply pesticides, is required by Air Force policy (AFI 32-1053).
- Air Force policy requires GEM Plans to "minimize or eliminate potential negative impacts to the environment and the surrounding community" (AFI 32-7064, Chapter 12.4).
- Use of native vegetation is supported by Air Force policy (AFI 32-7064, Chapter 12.3) and the Under Secretary of Defense Memo (see Introduction, *Why is pollinator conservation important to the Air Force*).
- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions that could occur if the species becomes federally listed.
- Use of native vegetation in out-of-play areas will reduce water usage, maintenance costs, and pest problems.
- Reduced mowing in out-of-play areas will reduce costs and our carbon footprint.
- Reduced pesticide use and targeting pesticide application will reduce costs, increase effectiveness, and promote healthy ecosystems where native predators and parasites will help control pests.
- Players may enjoy seeing pollinators (e.g., hummingbirds and butterflies) while playing.
- Help pollinators by:
    - Reducing mowing in "out-of-play" areas.
    - Planting additional native flowering plants and bunch grasses in out-of-play areas and as buffers around water hazards.
    - Managing habitat in out-of-play areas to provide nesting and overwintering sites (snags, stems with hollow or soft, spongy centers, open soil, butterfly host plants) for pollinators.
    - Using IPM to address pest problems, including:
        - Monitoring and establishing action thresholds to determine when to treat a pest problem.
        - Using cultural, physical/mechanical, and biological methods to control pests.

        - When pesticides are necessary:
            - Select pesticides and formulations with low toxicity to pollinators and low persistence in the environment. Avoid use of methyl isothiocyanate, which if not applied in strict adherence to the label can become waterborne, where it is highly toxic.
            - Use the lowest effective application rate.
            - Target pesticide application by selecting pesticides specific to the pest problem and applying them directly to the pest (e.g., paint stumps or spray leaves directly, rather than using trucks).
            - Minimize exposure of pollinators to pesticides through timing (e.g., late in the day or overnight, in low winds) and application method.
    - Removing invasives plants.

TARGET AUDIENCE 10: CONSTRUCTION PERSONNEL (INCLUDING CONTRACTORS)

Goals:

1. Limit soil disturbance and areas where heavy equipment travels and operates.
2. Offer the installation Natural Resources program the opportunity to salvage native plants or collect their seeds.
3. Use native plants for landscaping near buildings and parking lots.

Potential Messages:

- Certain pollinator species are declining or at risk of declining. Proactive measures implemented now to address pollinator declines may prevent regulatory restrictions on construction projects that could occur if the species becomes federally listed.
- Limiting where heavy equipment travels will reduce damage to vegetation. This will reduce project costs because a smaller area will need to be re-planted.
- Limiting soil disturbance and compaction will reduce destruction of native vegetation and pollinator nests.
- Providing the Natural Resource Program the opportunity to salvage plants or collect seed for areas to be cleared will help save the installation funds and reflect positively on your company.
- Using native vegetation will give your project and the installation a local character so personnel realize they are in (fill in the state or habitat type where the installation is located, e.g., the Sonoran Desert).

TARGET AUDIENCE 11: INSTALLATION RESIDENTS AND VISITORS

Goals:

1. Understand the benefits to the Air Force mission of changes they may see in land management on the installation to incorporate native landscaping, pollinator conservation measures, and reduced pesticide use.
2. Understand the actions they can take to help conserve pollinators, such as using native plants for landscaping, providing pollinator habitat and reducing pesticide use.
3. Assist with pollinator conservation or monitoring projects on the installation, such as those done for NPLD.

Potential Messages:

- Diverse natural habitats are important for realistic overflights and training missions, buffers for local communities, and long-term sustainability of our natural heritage. Conservation of pollinators promotes healthy diverse habitats because of their essential role in plant reproduction.
- There have been declines in pollinators, including certain bumble bees, butterflies, hummingbirds, bats, and honey bees. Proactive measures implemented now to address declines may prevent regulatory restrictions to future operations and training that could occur if the species were federally listed.
- Reducing and targeting pesticide use is part of IPM, which is Air Force policy (AFI 32-1053). It will reduce costs for chemicals, promote healthy ecosystems where native predators and parasites will help control pests and benefit pollinators.
- Eliminate breeding sites for mosquitoes by eliminating standing water. Change water in bird baths once or twice weekly (to prevent development of larval mosquitoes) and turn over or cover unused buckets and pots to eliminate standing water.
- The installation may be changing landscaping (e.g., reducing mowing) to provide food and shelter for pollinators. This may offer additional opportunities for observing and photographing nature (e.g., butterflies and birds).
- Pollinator conservation will reduce water usage, maintenance costs, pest problems and our carbon footprint.
- Help pollinators by:
    - Planting native plants in your yard/garden.
    - Providing habitat for pollinators (snags, stems with hollow or soft, spongy centers, open soil, butterfly host plants).
    - Reducing pesticide use outdoors.
- Native vegetation on the installation gives the installation a local character.
- Pollinators contribute over $29 billion to the U.S. economy through services to crops. Nearly 75% of crops rely on animal pollinators, including strawberries, pumpkins, tomatoes, blueberries, apples.

Pollinator conservation provides opportunities for installation residents to observe and photograph nature (photo: Ryan Hagerty/USFWS)

Sample educational signage for a pollinator garden (credit: USFWS; artwork: Tim Knepp)

SECTION 4. B. OUTREACH PROGRAM IMPLEMENTATION AND EVALUATION

HIGHLIGHTS

- Develop an outreach program implementation strategy, including:
  - Identifying the products (e.g., presentations, fact sheets, etc.) that will work best for the target audience
  - Who will develop the products
  - The time-line
  - Funding sources, if needed
- Determine how to evaluate effectiveness of the outreach program so that adjustments can be made if actions do not fully meet the goals

HELPFUL WEBSITES

- See DoD websites listed in Section 4.A.2
- DoD Pollinator Initiatives website: http://www.dodpollinators.org/index.html
- USFWS pollinator portal: https://www.fws.gov/pollinators
- FS pollinators webpage: https://www.fs.fed.us/wildflowers/pollinators/index.shtml
- Monarch Joint Venture resources: https://monarchjointventure.org/resources/downloads-and-links/
- Pollinator Partnership learning center: http://www.pollinator.org/usefulresources
- The Xerces Society for Invertebrate Conservation pollinator page: https://xerces.org/pollinator-conservation/

An outreach program implementation strategy is needed to move from the planning to implementation phase. Develop the strategy with the target audience, goals, and messages in mind. First, decide what communication product or products (e.g., presentations, fact sheets, briefing papers, glossy brochures, signage, displays, training, etc.) will work best for each target audience. For example, managers likely will want something short, such as briefing paper, explaining why any changes are important to Air Force missions. A pesticide applicator may need additional information and training about reducing pesticide impacts to pollinators and to make decisions about pest management. A kiosk, signage or a glossy brochure may be the right product for visitors. Once the outreach product is selected, determine who will develop the materials and the time-line for doing so. If relevant, identify others that need to be notified about the outreach efforts and potential partners in implementing the outreach program.

Use the information in previous sections of this *Reference Guide* to insert into communications products. In addition, factsheets and brochures that could be used as part of an outreach program can be found on websites, such as:

- DoD websites listed in Section 4.A.2
- DoD Pollinator Initiatives website
- USFWS pollinator portal

- FS pollinators webpage
- Monarch Joint Venture
- Pollinator Partnership learning center
- The Xerces Society for Invertebrate Conservation pollinator page

Next, determine how to evaluate the effectiveness of the outreach program. Part of the evaluation should be whether the goal(s) established for the target audience are being fully met. Collect or obtain data to determine whether the goals are fully met. Some sources of data could be:

- Collected by observation (e.g., are more native plants being used for landscaping?)
- Obtained for reporting purposes (e.g., comparing volume of pesticides used from one year to the next or amount of specific chemicals used from one year to the next)
- Collected from a survey or test of the target audience or a subgroup

It may be helpful to develop interim evaluations for larger outreach programs to assure maximum effectiveness of resources. An example would be to test the effectiveness of the message with the target audience and then refine if needed, before developing printed products. Then, produce a small run of printed products to evaluate their effectiveness before producing large quantities.

If the outreach goals are not being fully met, it would be helpful to determine whether the problem stems from the message, the type outreach materials, or something else. This information is needed to adjust the outreach program so that the goal(s) are fully met.

Signs can explain changes in land management (photo: Nova Clarke/USFWS)

SECTION 5: PARTNERSHIPS FOR POLLINATOR CONSERVATION OFF-INSTALLATION

This section provides information on multi-organizational partnerships that focus on or include pollinator conservation in their activities. Working with them may be helpful. The section also provides information on DoD funding sources that can be used for pollinator conservation work in partnership with others.

Developing a new partnership or participating in an existing partnership to further pollinator conservation can be beneficial to the Air Force. When key habitat for a pollinator of conservation concern is located off-installation, a successful partnership could help reduce the regulatory burden on the Air Force and benefit the pollinator population. In areas where encroachment is an issue, a partnership may be able to assist in reducing encroachment, while benefitting pollinator conservation. Partnerships that work at a landscape scale may be able to connect pollinator populations across large landscapes, increasing their resiliency in the face of climate change and other threats. Partnerships can also be a source of data and technical information about pollinators, and sometimes funding for research, restoration, or recovery.

Two programs, the Legacy Resource Management Program (Legacy program), and the Readiness and Environmental Protection Integration Program (REPI), exist within DoD that can provide funding for both large and small pollinator conservation projects.

Tagging monarch butterflies
(photo: Brett Billings/USFWS)

SECTION 5. A. PARTNERSHIPS AND COLLABORATIONS

5. A. 1. North American Pollinator Protection Campaign

HIGHLIGHTS

- The North American Pollinator Protection Campaign (NAPPC) is a diverse collaboration working to encourage the health of resident and migratory pollinating animals in North America
- P2 administers NAPPC
- DoD has an MOU with P2 to provide a framework for conservation and management of pollinators and their ecosystems

HELPFUL WEBSITES

- NAPPC: www.nappc.org
- P2: www.pollinator.org
- MOU between DoD and P2: http://www.denix.osd.mil/nr/otherlinks/policy-and-guidance/mou-between-dod-and-the-pollinator-partnership-request-for-coordination-2014/
- Information and sign up for Pollinator listserve: https://lists.sonic.net/mailman/listinfo/pollinator
- DoD Environment, Safety and Occupational Health Network and Information Exchange (DENIX) Website: http://www.denix.osd.mil/

The North American Pollinator Protection Campaign (NAPPC) is a collaboration of over 160 partners from government, academia, private industry and non-profits working to encourage the health of resident and migratory pollinating animals in North America. NAPPC is administered by P2, a non-profit organization. Signature initiatives include National Pollinator Week, development of regional planting guides for pollinators, and an annual working symposium to bring partners together and move initiatives forward via Task Forces. The mission of NAPPC is to:

- Raise public awareness and education and promote constructive dialogue about pollinators' importance to agriculture, ecosystem health, and food supplies.
- Encourage collaborative, working partnerships among participants and with federal, state and local government entities and strengthen the network of associated organizations working on behalf of pollinators.
- Promote conservation, protection and restoration of pollinator habitat.
- Document and support scientific, economic and policy research.

The Pollinator Partnership maintains a comprehensive website of freely downloadable information about pollinators and a listserve for sharing information about pollinators (NAPPC, 2017; P2, 2017).

The DoD Memorandum of Understanding (MOU) with P2 (signed February 9, 2015) establishes a framework of cooperation and coordination to conserve and manage pollinators and their ecosystems. Under this MOU, Pollinator Partnership identified the pollinators of threatened, endangered, rare and at risk plant species for DoD installations in the southwest and southeast (Projects 08-391 and 09-391, respectively). This information can be found on the DoD Environment, Safety and Occupational Health Network and Information Exchange (DENIX) (DoD, 2017b).

5. A. 2. Monarch Joint Venture

HIGHLIGHTS

- Monarch Joint Venture (MJV) is a partnership working together to protect monarchs and their migration across the lower 48 United States
- MJV is guided by the North American Monarch Conservation Plan (2008) and an annually updated partnership document, the *Monarch Conservation Implementation Plan*

HELPFUL WEBSITES

- MJV: http://monarchjointventure.org/
- Monarch Conservation Implementation Plan: http://monarchjointventure.org/our-work/
- North American Monarch Conservation Plan: http://www3.cec.org/islandora/en/item/2350-north-american-monarch-conservation-plan-en.pdf
- MJV funded projects: http://monarchjointventure.org/our-work/mjv-funded-projects/
- Monarch Conservation webinar series: https://nctc.fws.gov/topic/online-training/webinars/monarch-conservation.html

The Monarch Joint Venture (MJV) is a partnership of approximately 65 federal and state agencies, non-governmental agencies, and academic programs working together to protect monarchs and their migration across the lower 48 United States. MJV is guided by the North American Monarch Conservation Plan (Commission for Environmental Cooperation (CEC) Secretariat, 2008) and an annual *Monarch Conservation Implementation Plan*. Projects encompass habitat conservation and enhancement, research and monitoring, education and outreach and milkweed conservation. Recently funded projects include assessing the status of western monarch overwintering sites and developing a tool to assess monarch breeding habitat.

Information on funded projects can be found on the MJV website (Wendy Caldwell, pers. comm., 2017; MJV, 2017).

MJV accomplishes its goals through facilitating information sharing, partnership building, and carrying out identified conservation priorities. They disseminate information through an email listserve; co-host a Monarch Conservation webinar series with USFWS; and host an annual meeting for information sharing and networking, as well as working group discussions on a variety of topics. The MJV website serves as a clearinghouse for monarch conservation information, including basic information on monarch biology, threats, citizen science projects, and a variety of freely downloadable fact sheets (Wendy Caldwell, pers. comm., 2017; MJV, 2017).

Monarch butterfly with tag (photo: Ryan Moehring/USFWS)

5. A. 3. Western Hummingbird Partnership

HIGHLIGHTS

- The Western Hummingbird Partnership (WHP) funds and conducts research, monitoring, restoration and education on western hummingbirds
- Information on hummingbird biology, forage plants, citizen science projects, and a literature database can be found on the WHP website

HELPFUL WEBSITE

- WHP: http://www.westernhummingbird.org

The Western Hummingbird Partnership (WHP) supports projects, develops programs and builds partnerships to help hummingbirds thrive. Partners collaborate to conduct monitoring and research to determine what hummingbirds need to survive, reproduce and thrive; conduct habitat restoration; and educate managers, policy makers and the public on hummingbirds conservation needs. WHP funds projects through an annual competitive process. Current and recent projects include summarizing the current status of rufous hummingbirds, phenology of plants utilized by hummingbirds, development of regional planting guides for hummingbirds, research on exposure to pesticides, impacts of fire, and hummingbird movement (WHP, 2017; Susan Bonfield, pers. comm., 2017).

The WHP website provides information about hummingbirds, including their biology, forage plants, a literature database, citizen science projects, and a variety of other educational resources.

Anna's Hummingbird (photo: Lee Karney/USFWS)

5. A. 4. Hummingbird Monitoring Network

HIGHLIGHTS

- The Hummingbird Monitoring Network (HMN) established and maintains a long-term monitoring network of sites across North America to understand hummingbird demography, population trends, migration and patterns of movement
- HMN conducts research on and provides education material about hummingbirds

HELPFUL WEBSITES

- HMN: http://www.hummonnet.org

The Hummingbird Monitoring Network (HMN) is a science-based non-profit that works to conserve hummingbird diversity and abundance throughout the Americas through research, monitoring, education and habitat restoration. HMN has a tri-national long-term monitoring program (including banding birds) at 25 to 30 sites across North America. Monitoring sites are selected based on geographic factors and vegetation type. The information collected includes demographic data, timing of migration, movement patterns and population trends. Partners from federal and state agencies, non-government organizations, academia, and citizen scientists collect the data. HMN educates and engages citizen scientists and land managers, increasing awareness and knowledge of hummingbird conservation needs, through its monitoring program (HMN, 2017).

HMN conducts research on topics such as hummingbirds and climate change, community interactions and monitoring to assess restoration effectiveness. The HMN website provides monitoring data and information on the habitat components needed by hummingbirds, as well as general information about hummingbirds (HMN, 2017).

Rufous Hummingbird (photo: Alan Schmierer CC0 1.0)

5. A. 5. Partners in Flight

HIGHLIGHTS

- Partners in Fight (PIF) focuses on landbird conservation across the Americas
- Three hummingbird species are on the PIF Watch List
- DoD has its own PIF program that promotes proactive conservation to maintain healthy landscapes and training lands
- DoD PIF works on and off military lands to determine bird status, facilitate conservation partnerships and information sharing, and provide a framework for incorporating bird management into INRMPs

HELPFUL WEBSITES

- PIF: https://www.partnersinflight.org/
- 2016 Landbird Conservation Plan: https://www.partnersinflight.org/resources/the-plan/
- Other PIF bird conservation plans: https://www.partnersinflight.org/resources/
- DoD PIF: http://www.dodpif.org/
- DoD PIF Strategic Plan: https://www.partnersinflight.org/resources/strategic-plan-pif-dod/

Partners in Flight (PIF) is a network of over 150 partner organizations across the Western Hemisphere whose mission is "Keeping common birds common and helping species at risk through voluntary partnerships." PIF partners are engaged in all aspects of landbird conservation including science, research, planning, and policy development, land management, monitoring, education, and outreach. In the U.S. and Canada, activities are guided by the *2016 Landbird Conservation Plan* (*Plan*). The *Plan* provides new assessments, tools, and recommendations to address threats to landbirds. Within the *Plan*, 86 "Watch List" species are identified as of highest conservation concern at the continental (range-wide) scale. Among these are three pollinator species: Allen's, Lucifer, and Rufous Hummingbirds. Other PIF's bird conservation plans include habitat management actions that benefit hummingbirds and other pollinators that occur across the United States (PIF, 2017, and Rosenberg, et al., 2016).

PIF programs also conserve lesser-known bird pollinators and birds that are pollinators while overwintering in the tropics. Examples include the Gilded Flicker, a PIF Watch List species that is a pollinator for saguaro cacti, and the Tennessee Warbler and Orchard Oriole, species that are incidental pollinators while overwintering in the tropics.

DoD personnel work closely with the PIF program through DoD PIF. Their work sustains and enhances the military mission through proactive, habitat-based conservation and management strategies that maintain healthy landscapes and training lands. DoD PIF works beyond installation boundaries to facilitate cooperative partnerships, determine the status of bird populations, and prevent the listing of additional birds as threatened or endangered (DoD PIF, 2017).

The DoD PIF has a Strategic Plan (DoD Natural Resources Program, 2014, and Paul Jurena, pers. comm., 2017), which provides a coordinated framework for incorporating bird habitat management into INRMPs. The Strategic Plan has goals and priorities in nine key areas:

- Stewardship
- Partnerships/cooperation
- Communications
- Habitat and species management
- Bird/Wildlife aircraft strike hazard (BASH)
- Monitoring
- Research
- Information and education
- Enhancing the quality of life

5. A. 6. Migratory Bird Joint Ventures

HIGHLIGHTS

- Migratory Bird Joint Ventures (MBJVs) are collaborative regional partnerships that focus on conserving habitat for priority bird species, other wildlife, and people
- MBJVs work at a landscape-scale to implement national and international bird conservation plans
- MBJVs focus on creating healthy diverse habitats will often benefit pollinators
- At least one MBJV is intentionally incorporating pollinator conservation in their habitat restoration

HELPFUL WEBSITES

- MBJV: https://www.fws.gov/birds/management/bird-conservation-partnership-and-initiatives/migratory-bird-joint-ventures.php
- And http://mbjv.org/

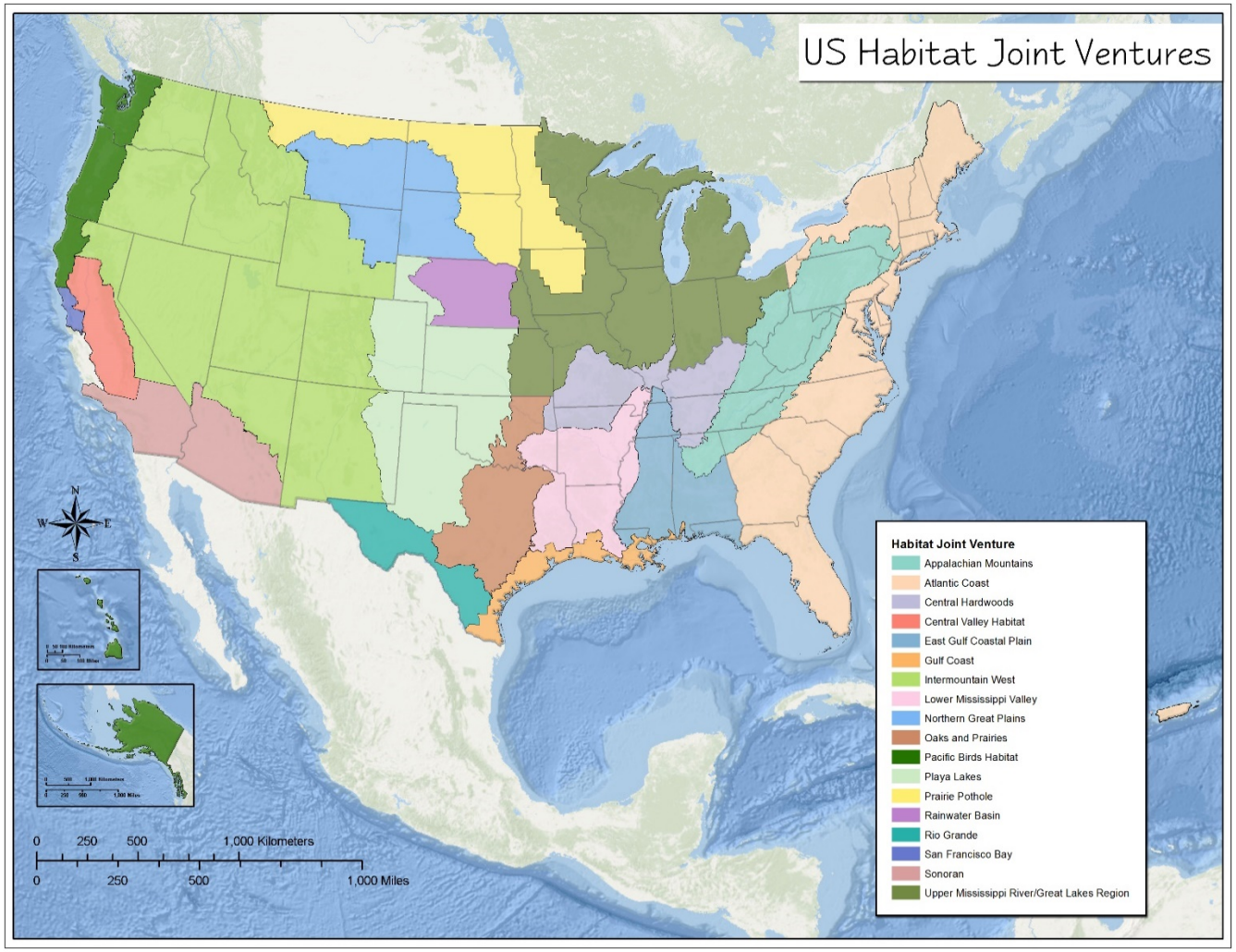
Migratory Bird Joint Ventures (MBJVs) are self-directed, collaborative, regional partnerships of government agencies, non-profit organizations, corporations, tribes, and individuals that conserve habitat for priority bird species, other wildlife, and people. MBJVs bring diverse partners together to implement national and international bird conservation plans at a landscape-scale. There are 18 habitat-based joint ventures (JVs) in the United States (Figure 6), as well as 3 species-based (arctic goose, black duck and sea duck) JVs. MBJVs are engaged in a wide variety of activities, including biological planning, conservation design, prioritizing projects, monitoring populations, evaluating actions, research, education, outreach and funding projects and activities (MBJVs, 2017, and USFWS, 2017b).

An example of a JV project benefiting bird pollinators (e.g., Gila Woodpecker and White-winged Dove) on military lands is the *Coordinated Sonoran Desert Breeding Bird Monitoring* project. The project received funding from both the Legacy program (Section 5.B.1) and the Sonoran JV. The Sonoran JV also provides technical assistance to the project (e.g., help with study design, etc.). The project is using monitoring to determine distribution, habitat use and population trends for breeding birds that are at risk or poorly monitored. It will provide information needed to manage these at-risk species whose ranges include DoD lands so that actions can be taken to prevent further declines that could result in regulatory restrictions (Carol Beardmore, pers. comm., 2017; DoD PIF, 2017).

While MBJVs focus on habitat restoration for migratory birds, much of the work they do in key pollinator habitats (e.g., grasslands and prairies) is likely to benefit a wide variety of pollinators. In some cases, MBJVs are intentionally incorporating pollinator conservation into their habitat restoration work. For example, both the Rio Grande JV and the Oaks and Prairies JV are conducting a restoration program for degraded native grasslands to benefit monarch butterflies, as well as grassland birds. Grasslands within both JVs provide important habitat for monarch butterflies migrating between wintering grounds in Mexico and summer breeding areas in the United States. Goals of the project are to improve habitat quality, quantity and connectivity for monarchs. These JVs use the Grassland Restoration Incentive Program (GRIP) to provide direct payment to landowners for conducting pre-approved management practices to restore native grassland. A network of partners provides site-specific technical recommendations for landowners and looks for opportunities to leverage funding through other programs. Results are monitored so that management can be changed over time to increase success (Jesús G. Franco, pers. comm., 2017).

A White-winged Dove, one of the birds included in the Coordinated Sonoran Desert Breeding Bird Monitoring project (photo: Lee Karney/USFWS)

Figure 6: U.S. Migratory Bird Habitat Joint Venture Map



5. A. 7. Sentinel Landscapes Partnership

HIGHLIGHTS

- Sentinel Landscapes Partnerships protect the military mission by preserving nearby working and rural landscapes and conserving habitat and natural resources
- The Sentinel Landscapes Partnership (Partnership) was formed through an MOU among DoD, DOI and USDA
- The agencies in the partnership work together to sustain the military mission and conserve habitat and natural resources by identifying opportunities to leverage funding and actions to promote voluntary expansion and compatible management of working lands
- The Joint Base Lewis-McChord Sentinel Landscape Partnership is conserving native prairie habitat that is home to Taylor's checkerspot butterfly, a pollinator, as well as other listed species

HELPFUL WEBSITES

- Sentinel Landscapes website: http://sentinellandscapes.org/
- Sentinel Landscapes MOU: http://sentinellandscapes.org/media/1041/final_sentinel_landscapes_mou.pdf
- Joint Base Lewis-McChord Sentinel Landscape Partnership: http://sentinellandscapes.org/explore/

The Sentinel Landscapes Partnership (Partnership) among DoD, DOI and USDA protects the military mission by preserving the working and rural character of landscapes near bases and conserving habitat and natural resources. The military mission is typically protected by actions on nearby lands that reduce, prevent or eliminate restrictions and development that inhibit military testing and training. The Partnership was formed through an MOU among the three Departments in 2013. The Partnership is coordinated at the national level through the Sentinel Landscapes Federal Coordination Committee (USDA, et al., 2017).

There are currently six Sentinel Landscapes designated. Additional Sentinel Landscapes may apply and be designated in the future. All Sentinel Landscapes must fulfill the following requirements:

1. Include an anchor military installation with a military mission that benefits from compatible land uses outside of the installation's boundaries.
2. Define a landscape associated with the anchor installation where Federal, state, local, and private programs and efforts can be coordinated to support voluntary conservation and landowner involvement.

3. Articulate goals and outcomes that promote and sustain compatible land uses for military operations while providing tangible benefits to conservation and working lands within the defined Landscape.

The Departments work together to help sustain the military mission and conserve natural resources by identifying opportunities to promote voluntary expansion and compatible management of working lands. They provide landowner incentives using available tools. The Departments coordinate with State agencies to promote consistency in considering and designating Sentinel Landscapes in state plans (e.g., State Wildlife Action Plans (SWAPs)) (USDA, et al., 2017).

The Joint Base Lewis-McChord Sentinel Landscape Partnership is an example of a Sentinel Landscape that benefits a pollinator. The partners are conserving prairie habitat in the Puget Sound area for Taylor's checkerspot butterfly, as well as other species. Working farms, forests, and ranches surrounding the Base offer opportunities to support the military mission by preventing encroachment and conserving prairie habitat to support federally listed species. The Federal partners, working with state and local government and non-government organizations, have conserved over 5,000 acres of prairie already (USDA, et al., 2017).

Taylor's checkerspot, an endangered butterfly addressed in the Joint Base Lewis-McChord Sentinel Landscape Partnership (photo: Aaron Barna/USFWS CC BY 2.0)

5. A. 8. Landscape Conservation Cooperatives

HIGHLIGHTS

- Landscape Conservation Cooperatives (LCCs) bring together partners to set shared priorities and goals and then fill information gaps by developing science and support tools to assist land managers to sustain natural and cultural resources at a landscape scale
- Many LCCs are coordinating with State Fish and Wildlife Agencies to help them develop and implement their SWAPs
- The Eastern Tallgrass Prairie and Big Rivers LCC is developing tools for monarch conservation in urban areas
- Air Force is currently working with the Peninsular Florida LCC to prioritize conservation opportunities that provide mission flexibility, and prevent and abate encroachment, while helping to comply with legal requirements for at-risk species

HELPFUL WEBSITES

- LCC Network: https://lccnetwork.org/
- Urban Monarch Conservation Guidebook: https://tallgrassprairielcc.org/resource/urban-monarch-conservation-guidebook
- Pollinator Habitat Mapping Tools: https://tallgrassprairielcc.org/resource/pollinator-habitat-mapping-tools
- Peninsular Florida LCC – Air Force partnership: http://peninsularfloridalcc.org/page/pflcc-af-partnership

There are 22 Landscape Conservation Cooperatives (LCCs) across North America and the Pacific and Caribbean Islands that bring together partners from Federal, State and local governments; Tribes and First Nations; nongovernmental organizations; universities and interested public and private organizations to set shared conservation goals and priorities and increase partners' collective science and management capacity (Figure 7 and Table 13). LCCs, through the LCC Network, share a common vision for "landscapes capable of sustaining natural and cultural resources for current and future generations." Each partnership is self-directed and science-driven. LCCs are coordinated through an LCC Network Coordinator and other Network Staff. The LCC Council provides policy-level coordination and support for the entire LCC Network (LCC Network, 2017).

LCC partnerships focus on how to conserve landscapes that span multiple jurisdictions and authorities in order to support diverse natural and cultural resources. Many LCCs have online planning tools (e.g., atlases) that bring together multiple data sets to aid in identifying important

areas and opportunities for conservation. Their models and tools incorporate future scenarios and adaptive management.[62] For example, the Eastern Tallgrass Prairie and Big Rivers (ETPBR) LCC and the Upper Midwest and Great Lakes LCC are working with states to identify shared multi-state conservation priorities based on individual SWAPs. Pollinator conservation (e.g., native bees and monarch butterflies) was identified as a shared priority across multiple states. States are collaborating with LCCs to collect data to understand more about conservation actions needed for pollinators and identify an approach for conservation across broad landscapes (LCC Network, 2017; Kelly Meyers, pers. comm., 2017).

In addition, ETPBR LCC, along with neighboring LCCs, are working on pollinators in urban areas. Tools for communities seeking to improve habitat for monarchs butterflies and other pollinators include an Urban Monarch Conservation Guidebook for city planners and conservation practitioners interested in identifying the best places and methods to create people- and pollinator-friendly habitat in urban areas. They also developed Pollinator Habitat Mapping Tools to help determine current milkweed abundance in urban areas and identify the land-use types with the greatest potential for supplementing milkweed and nectar sources. Creating pollinator habitat helps cities address other priorities by creating cleaner, safer, and healthier communities. The same would hold true for Air Force installations (ETGPBR LCC, 2017; Urban Monarch Conservation Team, 2017).

An example of an LCC that is working with the Air Force to sustain military readiness through conservation partnerships is the Peninsular Florida LCC. A pilot project was initiated in 2015 to develop a *Strategic Plan for Sustaining Military Readiness through Conservation Partnerships.* The plan includes a geospatial analysis of the opportunities and constraints to managing natural resources across all eight Florida Air Force installations. Based on the analysis, the plan prioritizes conservation opportunities that will provide mission flexibility, and prevent and abate encroachment, while helping to comply with legal requirements (e.g., mitigation for listed, candidate, proposed and state-listed species). Potential projects and funding solutions that leverage the resources of all partners and contribute to conservation across Florida beyond installation boundaries are identified. The plan will not replace installation INRMPs. It will be used to enhance INRMPs, plan for conservation needs shared among installations, and leverage opportunities off installation lands. This proactive approach will sustain military readiness and mission flexibility, while contributing to species recovery. Building the plan through the LCC partnership forum facilitates leveraging species and habitat work led by partners (Peninsular Florida LCC, 2017 and Catherine Phillips, pers. comm., 2017).

[62] All LCC projects and products will be catalogued in USGS ScienceBase platform no later than mid-2018.

Figure 7: Landscape Conservation Cooperative Network Map

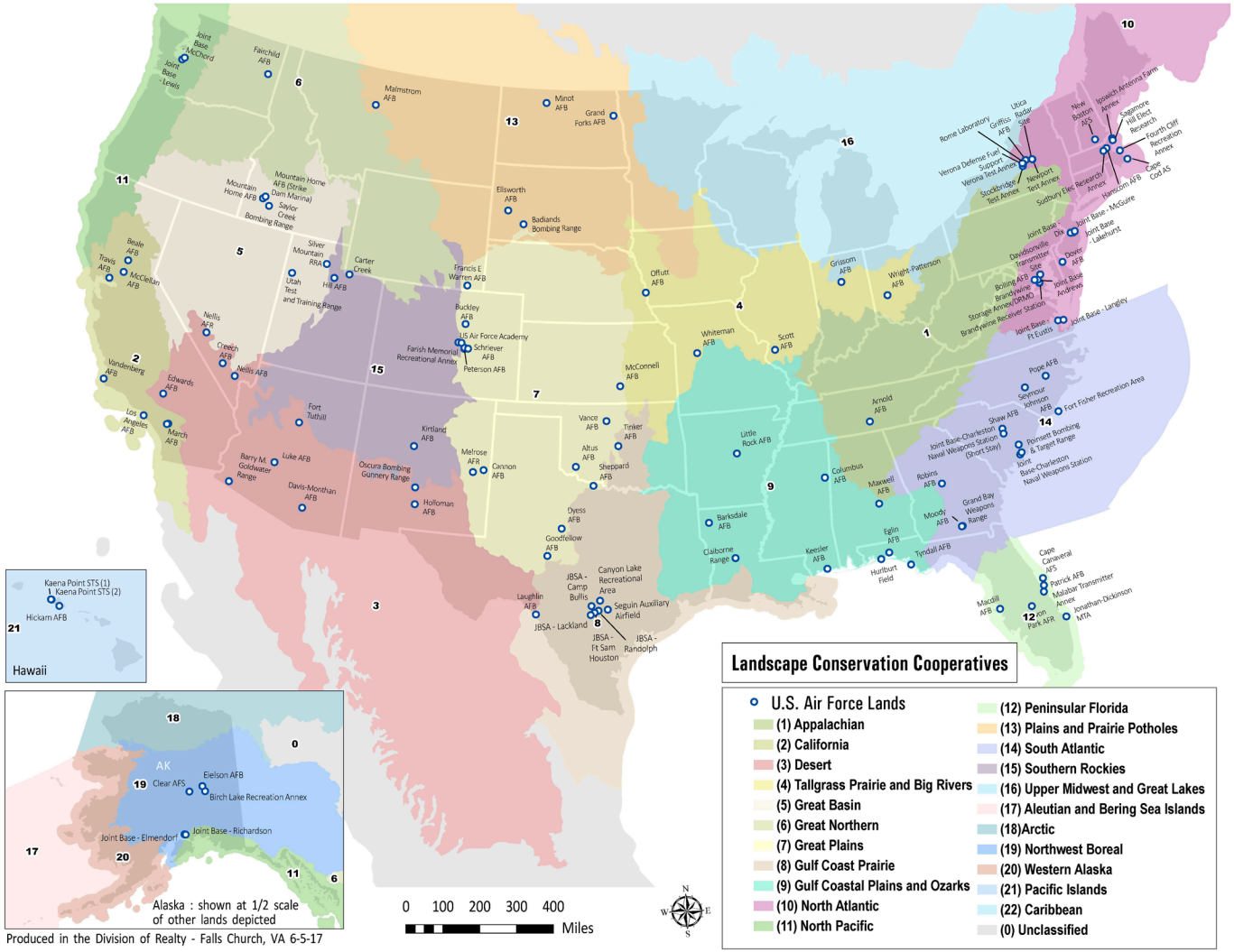


Table 13: U.S. Air Force lands and LCCs

Air Force installation name	State	LCC
Altus AFB	OK	Great Plains
Arnold AFB	TN	Appalachian
Avon Park AFR	FL	Peninsular Florida
Badlands Bombing Range	SD	Plains and Prairie Potholes
Barksdale AFB	LA	Gulf Coastal Plains and Ozarks
Barry M. Goldwater Range	AZ	Desert
Beale AFB	CA	California
Birch Lake Recreation Annex	AK	Northwest Boreal
Bolling AFB	DC	North Atlantic
Brandywine Receiver Station	MD	North Atlantic
Brandywine Storage Annex/DRMO	MD	North Atlantic
Buckley AFB	CO	Great Plains
Cannon AFB	NM	Great Plains
Canyon Lake Recreational Area	TX	Gulf Coast Prairie
Cape Canaveral AFS	FL	Peninsular Florida
Cape Cod AS	MA	North Atlantic
Carter Creek	UT	Southern Rockies
Claiborne Range	LA	Gulf Coastal Plains and Ozarks
Clear AFS	AK	Northwest Boreal
Columbus AFB	MS	Gulf Coastal Plains and Ozarks
Creech AFB	NV	Desert
Davidsonville Transmitter Site	MD	North Atlantic
Davis-Monthan AFB	AZ	Desert
Dover AFB	DE	North Atlantic
Dyess AFB	TX	Great Plains
Edwards AFB	CA	Desert
Eglin AFB	FL	Gulf Coastal Plains and Ozarks
Eielson AFB	AK	Northwest Boreal
Ellsworth AFB	SD	Plains and Prairie Potholes
Fairchild AFB	WA	Great Northern

Air Force installation name	State	LCC
Farish Memorial Recreational Annex	CO	Southern Rockies
Fort Fisher Recreation Area	NC	South Atlantic
Fort Tuthill	AZ	Desert
Fourth Cliff Recreation Annex	MA	North Atlantic
Francis E Warren AFB	WY	Great Plains
Goodfellow AFB	TX	Great Plains
Grand Bay Weapons Range	GA	South Atlantic
Grand Forks AFB	ND	Plains and Prairie Potholes
Griffiss AFB	NY	North Atlantic
Grissom AFB	IN	Eastern Tallgrass Prairie and Big Rivers
Hanscom AFB	MA	North Atlantic
Hickam AFB	HI	Pacific Islands
Hill AFB	UT	Great Basin
Holloman AFB	NM	Desert
Hurlburt Field	FL	Gulf Coastal Plains and Ozarks
Ipswich Antenna Farm Annex	MA	North Atlantic
Joint Base - Charleston Naval Weapons Station	SC	South Atlantic
Joint Base - Charleston Naval Weapons Station (Short Stay)	SC	South Atlantic
Joint Base - Dix	NJ	North Atlantic
Joint Base - Elmendorf	AK	Northwest Boreal
Joint Base – Ft. Eustis	VA	North Atlantic
Joint Base - Lakehurst	NJ	North Atlantic
Joint Base - Langley	VA	North Atlantic
Joint Base - McChord	WA	North Pacific
Joint Base - McGuire	NJ	North Atlantic
Joint Base - Richardson	AK	North Pacific AND Northwest Boreal
Joint Base Andrews	MD	North Atlantic
Joint Base San Antonio - Camp Bullis	TX	Gulf Coast Prairie
Joint Base San Antonio – Ft. Sam Houston	TX	Gulf Coast Prairie
Joint Base San Antonio - Lackland	TX	Gulf Coast Prairie

Air Force installation name	State	LCC
Joint Base San Antonio - Randolph	TX	Gulf Coast Prairie
Joint Base - Lewis	WA	North Pacific
Jonathan-Dickinson MTA	FL	Peninsular Florida
Kaena Point STS (1)	HI	Pacific Islands
Kaena Point STS (2)	HI	Pacific Islands
Keesler AFB	MS	Gulf Coastal Plains and Ozarks
Kirtland AFB	NM	Southern Rockies
Laughlin AFB	TX	Gulf Coast Prairie
Little Rock AFB	AR	Gulf Coastal Plains and Ozarks
Los Angeles AFB	CA	California
Luke AFB	AZ	Desert
Macdill AFB	FL	Peninsular Florida
Malabar Transmitter Annex	FL	Peninsular Florida
Malmstrom AFB	MT	Plains and Prairie Potholes
March AFB	CA	California
Maxwell AFB	AL	Gulf Coastal Plains and Ozarks
McClellan AFB	CA	California
McConnell AFB	KS	Great Plains
Melrose AFR	NM	Great Plains
Minot AFB	ND	Plains and Prairie Potholes
Moody AFB	GA	South Atlantic
Mountain Home AFB	ID	Great Basin
Mountain Home AFB (Strike Dam Marina)	ID	Great Basin
Nellis AFB	NV	Desert
Nellis AFR	NV	Great Basin AND Desert
New Boston AFS	NH	North Atlantic
Newport Test Annex	NY	North Atlantic
Offutt AFB	NE	Eastern Tallgrass Prairie and Big Rivers
Oscura Bombing Gunnery Range	NM	Desert
Patrick AFB	FL	Peninsular Florida
Peterson AFB	CO	Great Plains
Poinsett Bombing and Target Range	SC	South Atlantic

Air Force installation name	State	LCC
Pope AFB	NC	South Atlantic
Robins AFB	GA	South Atlantic
Rome Laboratory	NY	North Atlantic
Sagamore Hill Elect Research	MA	North Atlantic
Saylor Creek Bombing Range	ID	Great Basin
Schriever AFB	CO	Great Plains
Scott AFB	IL	Eastern Tallgrass Prairie and Big Rivers
Seguin Auxiliary Airfield	TX	Gulf Coast Prairie
Seymour Johnson AFB	NC	South Atlantic
Shaw AFB	SC	South Atlantic
Sheppard AFB	TX	Great Plains
Silver Mountain RRA	UT	Southern Rockies
Stockbridge Test Annex	NY	Upper Midwest and Great Lakes
Sudbury Elec Research Annex	MA	North Atlantic
Tinker AFB	OK	Gulf Coast Prairie
Travis AFB	CA	California
Tyndall AFB	FL	Gulf Coastal Plains and Ozarks
US Air Force Academy	CO	Southern Rockies AND Great Plains
Utah Test and Training Range	UT	Great Basin
Utica Radar Site	NY	North Atlantic
Vance AFB	OK	Great Plains
Vandenberg AFB	CA	California
Verona Defense Fuel Support	NY	Upper Midwest and Great Lakes
Verona Test Annex	NY	Upper Midwest and Great Lakes
Whiteman AFB	MO	Eastern Tallgrass Prairie and Big Rivers
Wright-Patterson AFB	OH	Eastern Tallgrass Prairie and Big Rivers

SECTION 5. B. FUNDS FOR PARTNERSHIPS

5. B. 1. Legacy Resource Management Program

HIGHLIGHTS

- The Legacy Resource Management Program (Legacy Program) funds DoD projects that preserve natural and cultural heritage
- Projects eligible for funding include regional management initiatives, habitat preservation, invasive species control, monitoring and predicting migratory patterns, archeological investigations, and Native American consultations
- The Legacy Program is guided by the principles of stewardship, leadership, and partnership
- Priority is given to projects that benefit multiple installations
- The Legacy Program funds NPLD projects on military lands
- Installations may apply for up to $6500 for NPLD natural and cultural restoration and enhancement projects through National Environmental Education Foundation (NEEF)

HELPFUL WEBSITES

- Legacy Program website: https://www.dodlegacy.org/Legacy/intro/about.aspx
- NPLD website for DoD: https://www.neefusa.org/resource/department-defense-natural-resources-program
- NPLD Pollinator projects from past years: http://www.dodpollinators.org/NPLD.html
- NEEF website (for applications): https://www.neefusa.org/grants

The Legacy Resource Management Program (Legacy Program) provides funding for DoD projects that support military readiness and preserve natural and cultural heritage. A Legacy program project can include regional ecosystem management initiatives, habitat preservation, invasive species control, monitoring and predicting migratory patterns of birds and animals, archaeological investigations, and Native American consultations. Priority is given to projects that benefit multiple installations (DoD, 2017a).

The Legacy Program is guided by the principles of: (1) stewardship, safeguarding its irreplaceable resources for future generations; (2) leadership, modelling respectful use of natural and cultural resources; and (3) partnership, utilizing knowledge and talents outside of DoD (DoD, 2017a).

In support of these principles, the Legacy Program emphasizes:

- Incorporating an ecosystem approach to maintain biological diversity and the sustainable use of land and water resources.

- Implementing an interdisciplinary approach that takes advantage of the similarities between DoD's natural and cultural resource plans and shares management methodologies and techniques across natural and cultural resource initiatives.
- Promoting understanding and appreciation for natural and cultural resources by encouraging greater awareness and involvement of the military and the public.
- Applying a regional approach (e.g., the Sonoran Ecosystem Management Initiative and Partners in Flight).
- Identifying innovative new technologies for more efficient and effective management.

The Legacy Program has a two-step funding process. The Legacy Program identifies areas of emphasis annually. Complete application information is found on the Legacy Program website.

The Legacy Program funds NPLD projects on military lands by providing funds to National Environmental Education Foundation (NEEF). Installations may apply to NEEF for up to $6500 for natural and cultural resource restoration and enhancement projects, such as regional ecosystem management, habitat preservation, invasive species control, and monitoring. Projects must meet all NEEF requirements (NEEF, 2017).

Pollinator garden at McConnell Air Force Base taking shape (photo: Laura Mendenhall/USFWS)

5. B. 2. Readiness and Environmental Protection Integration Program

HIGHLIGHTS

- The Readiness and Environmental Protection Integration (REPI) Program provides funding to address encroachment, land-use conflict issues, and regulatory restrictions that impact military activities
- REPI supports partnerships to acquire easements or work regionally across boundaries in support of the military mission and conservation
- The REPI Challenge encourages large scale conservation projects by providing sing large awards (up to $10 million in FY 17) for land transactions to eligible military bases
- REPI provides strategies, webinars, primers, and other resources to assist in addressing regulatory constraints

HELPFUL WEBSITES

- REPI website: http://www.repi.mil/
- Southeastern Regional Partnership for Planning and Sustainability: https://serppas.org
- Western Regional Partnership: http://wrpinfo.org/
- REPI primers: http://www.repi.mil/Resources/Primers/

The Readiness and Environmental Protection Integration (REPI) Program provides funding to:

- Address encroachment that can limit or restrict military training, testing and operations.
- Remove or avoid land-use conflicts near installations.
- Address regulatory restrictions that inhibit military activities.

The two main threats to the training mission are nearby incompatible development and regulatory restrictions on DoD lands to protect species and habitat under ESA (DoD, 2017c).

One component of REPI Program is the use of encroachment management partnerships among the Military Services, private conservation groups, and state and local governments. The partnerships share the cost of acquiring easements from willing sellers to preserve compatible land uses and natural habitats near military lands to help sustain military mission. Funds may also be provided for management of natural resources on protected lands where such management provides a benefit to military mission activities. Projects that provide multiple benefits to the community and environment and have strong cost sharing are encouraged.

REPI also supports large collaborative landscape partnerships that work across boundaries to maintain military readiness and promote conservation. Examples of partnerships supported by

REPI include the Southeastern Regional Partnership for Planning and Sustainability, the Western Regional Partnership, and the Sentinel Landscapes Partnership (Section 5.A.5) (DoD, 2017c).

The REPI Challenge is an initiative that provides single large awards (up to $10 million in FY17) for encroachment management partnerships around military installations and ranges. The Challenge's goals are "to cultivate projects that conserve land at a greater scale, test promising ways to finance land protection, and harness the creativity of the private sector and market-based approaches" (DoD, 2017c).

In addition to providing funding, REPI develops strategies and provides information and resources to address regulatory barriers and constraints (e.g., projects that conserve off-installation habitat to meet on-installation Endangered Species Act obligations). Further, REPI hosts webinars and has a variety of educational primers available for downloading from the website.

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