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Conserving Biodiversity on Military Lands – A Guide for Natural Resources Managers, 3rd Edition

Main Narrative

(Revised to address Legacy Program Technical Review comments)

NATURESERVE

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Conserving Biodiversity on Military Lands: A Guide for Natural Resource Managers

(Photo: Doug Ripley)

NatureServe

Center for Environmental Management
MILITARY LANDS

Contents

Preface

This 2021 update to the 2008 publication "Conserving Biodiversity on Military Lands- A Guide for Natural Resource Managers Handbook" has two principal aims. First, it endeavors to present an updated overview of the subject of biological diversity on Department of Defense (DoD) lands, one that includes discussions of current scientific thought and that reflects the many themes with increased significance to DoD natural resources managers. The second aim is to provide a forum for military natural resources managers to discuss biodiversity conservation and offer suggestions and ideas for biodiversity enhancement programs.

The Nature Conservancy prepared an original 1996 handbook for the DoD using the results of a yearlong "dialogue" conducted by the Keystone Center. In that effort, experts from the military, academia, private environmental organizations, and other federal and state land management agencies were brought together in a series of workshops to discuss strategies for enhancing biological diversity on military lands. In 2007-2008, the DoD Legacy Resource Management Program funded an update to the original resource through a grant to NatureServe. That 2008 revision was based on a review of the needs and opinions of military natural resources managers who provided their inputs either through individual conversations or an online questionnaire. Additionally, NatureServe conducted a three-day workshop at Arnold Air Force Base, Tennessee, in which key military natural resources managers from across the country met with scientific and management experts from The Nature Conservancy and NatureServe to develop a detailed outline for the new handbook. Military natural resources managers, both at the installation and headquarters levels, prepared many of the chapters. Others, such as Chapter 1 (the relationship of biodiversity and the military mission) and Chapter 2 (the science behind biodiversity conservation) were prepared by respected scientists with long associations with DoD environmental programs. Experienced science writers prepared the remaining chapters and also edited the entire handbook. This 2008 version included a large collection of case studies prepared by individual military natural resources managers that highlight the challenges and accomplishments of specific biodiversity conservation projects on many installations.

For this 2021 update, as with the previous update, NatureServe again facilitated a process to elicit inputs from DoD natural resource managers from all service branches and other staff via direct consultation and an extensive online survey. Based on this detailed feedback from DoD personnel and a review of existing content, this new version of the handbook encompasses the following significant revisions and updates:

- Adjustments to the emphasis put on various conservation and DoD policy topics in line with trends in the field of conservation science and DoD policies and practices (such as increased reference to climate change implications and ecosystem and landscape-scale conservation perspectives),

- A revised structure that presents a more logical and accessible presentation of information. This includes grouping chapters into three distinct parts: ‘Introduction and Key Challenges’, ‘Conservation in Practice in the DoD Context’, and ‘Key Topics in Conservation Management’. Guidance on these parts and the chapters arranged within them is presented below.
- A ‘matrix approach’ to chapters and case studies that acknowledges that most case studies included are representative of concepts in two or more chapters.
- A thorough index of key terms and place names to present a more thorough mapping of where concepts (many of which are closely interrelated) appear in the text and case studies.

It is clear from our outreach to practitioners that users of this handbook either use it or intend to use it for a variety of purposes and that consulting the resource for specific guidance on one or more topics of interest is a common use case (as opposed to reading it from start to finish). To assist with navigating the extensive content provided, we present below a ‘roadmap’ to the parts and chapters provided in hopes that users can more efficiently find what they need.

Finally, NatureServe and the Legacy Program remain committed to establishing a resource that can be updated and linked to additional interactive resources in an ongoing way. This will increase the relevance and value of the content at any given time and increase the potential to link to and from this resource to the growing number of documents and electronic resources relevant to the work of DoD natural resource managers.

Navigating This Handbook

Acknowledging that most readers won't be picking up this handbook and reading it from cover to cover, a review of the notes below should help any user understand how information and discussion has been organized and more effectively locate the information they need.

Part I. Introduction and Key Challenges

This set of chapters introduces the key conservation and natural resource management challenges faced in the Department of Defense (DoD) context, presents the key concepts and important current trends in the field of conservation, and demonstrates how conservation challenges must often be seen as a complex mix of ecological patterns and impacts and competing human interests. The growing issue of climate change often amplifies these challenges and makes identifying and applying solutions even more complex.

Chapter 1. Meeting the Military Mission Through Conserving Biodiversity

This chapter provides a compelling overview of why biodiversity is important to the military's mission and why DoD lands are so critical to the future of biodiversity in the US. Many topics introduced here are discussed in more detail in other parts of this guide.

Chapter 2. Understanding Biodiversity Conservation

This chapter introduces the science of biodiversity conservation and discusses many issues central to biodiversity conservation in the context of military lands.

Chapter 3. Challenges at the Nexus of Science and Policy

Today's natural resource managers must carefully blend science and policy. This short chapter discusses three issues that exemplify the need for this balance: Landscape and ecosystem management, encroachment, and climate change.

Part II. Conservation in Practice in the DoD Context

This set of chapters develops the legal and policy frameworks underpinning biodiversity management on military lands. The section starts with an overview of key laws and policies that define the conservation mission (such as the Endangered Species Act), provides an in-depth discussion of the central importance of Integrated Natural Resource Management Plans, and ends with chapters on the partnership and resourcing programs and opportunities the military has developed to ensure biodiversity conservation can be effectively balanced with mission readiness.

Chapter 4. Laws, Policies, and Programs

From the pivotal Sikes Act to more recent directives on climate change, this chapter is an inventory of some of the most important laws, policies, and programs that form the basis for many of the goals and mandates that natural resource managers face.

Chapter 5. The Integrated Natural Resources Management Plan: Foundations and Key Topics

The central importance of Integrated Natural Resources Management Plans (INRMPs) has increased since they were first mandated, and they are now recognized as a cornerstone of effective biodiversity management on military lands. This chapter represents an in-depth strategic guide to formulating and executing highly effective INRMPs.

Chapter 6. Partnerships to Achieve Conservation Goals and Sustain Training

Military bases and other installations are not islands; they are integral to the other federal, state, and private lands and waters that surround them. This chapter provides an inventory of key DoD partnership programs that help safeguard both mission readiness and biodiversity conservation.

Chapter 7. Funding Natural Resources Conservation on Military Lands

Staffing and financing effective biodiversity conservation activities is a challenge all over the world—and this is also true for activities on U.S. Military lands. This chapter summarizes current funding programs and opportunities that managers must understand and effectively navigate in order for their integrated plans to succeed.

Part III. Key Topics in Conservation Management

This set of chapters elaborates on many of the key topics introduced in Part I. Within the framework of the laws, policies, and programs discussed in Part II, managers will want to understand these topics to design effective biodiversity benchmarks, monitoring programs, and management strategies.

Chapter 8. Managing Landscapes and Ecosystems

Species and other elements of biodiversity depend on patterns and processes that often extend well beyond the boundaries of an individual installation. This chapter provides detailed information on understanding, monitoring, and managing to sustain ecosystems and landscapes.

Chapter 9. Managing for Threatened, Endangered and At-Risk Species

The legal frameworks around threatened, endangered and at-risk species define some of the most important mandates and objectives that natural resource staff must adhere to. This chapter provides detailed information on these laws and frameworks and reminds the reader of key concepts and approaches that are needed to be successful in managing for successful species and habitat outcomes.

Chapter 10. Invasive Species Management

Invasive species are a threat to biodiversity and training operations on most DoD lands. This chapter reviews the science of invasive species and presents approaches for combatting and mitigating their impacts.

Chapter 11. Balancing Biodiversity Conservation with Multiple Uses

Military installations and the lands and waters around them are increasingly being used to meet the diverse needs of surrounding communities. This chapter discusses some of these uses, how conflicts can arise, and what toolbox is needed to alleviate these conflicts.

Case studies

Ten case studies were either newly developed or updated for inclusion with this version of “Conserving Biodiversity on Military Lands: A Guide for Natural Resource Managers.” Since each of these has relevance to at least two chapters of the new guide, the following matrix provides a mapping of which case studies are considered.

	Part I			Part II				Part III			
Case studies	Chapter 1. Meeting the Military Mission Through Conserving Biodiversity	Chapter 2. Understanding Biodiversity Conservation	Chapter 3. Challenges at the Nexus of Science and Policy	Chapter 4. 4. Laws, Policies, and Programs Supporting Conservation and Natural Resource Management on and Around DoD Lands	Chapter 5. The Integrated Natural Resources Management Plan: Foundations and Key	Chapter 6. Partnerships to Achieve Conservation Goals and Sustain Training	Chapter 7. Funding Natural Resources Conservation on Military Lands	Chapter 8. Managing Landscapes and Ecosystems	Chapter 9. Managing for Threatened, Endangered and At-	Chapter 10. Invasive Species Management	Chapter 11. Balancing Biodiversity Conservation with Multiple Uses
Balancing Mission and Biodiversity at Fort Bragg	●										●
Wildlife Management and Climate Change– Marine Corps Base Hawaii	●					●			●	●	
Camp Ripley Sentinel Landscape	●		●	●		●	●	●			
Establishing Biosecurity for the Military Transportation Network within Joint Region Marianas Area of Responsibility		●							●	●	
A Landscape Approach to Manage Stressors for Multiple Federally Listed Species, Pohakuloa Training Area, Hawaiʻi		●						●	●		
Endangered Species Act Implementation, Dam Removal – Beale Air Force Base, California					●	●			●		
Habitat Conservation Planning— Beale Air Force Base, California					●			●	●		
Nene Conservation: U.S. Army Garrison-Pōhakuloa Training Area Helps with Endangered Species Success Story for the Hawaiʻi State Bird Using Off-Site Management						●			●	●	
Threatened and Endangered Species Management for the Palos Verdes Blue Butterfly -- Defense Fuel Support Point, California						●			●		
Yellow Crazy Ant Monitoring and Control at Marine Corps Base Hawai'i						●				●	

Foreword

In an era of increasingly demanding and ever-changing requirements for our nation's military forces, the conservation of biological diversity on the lands used to train those forces, and to test the weapons they will need in battle, may strike some as a curious, and even unnecessary, priority. But long experience by the Department of Defense (DoD) with the management of the natural resources on its nearly 30 million acres of land has shown that the environmental health of these lands is essential for realistic and sustainable military testing and training.

Biological diversity refers to the variety of life and the ecological processes that sustain it. It plays an essential role in the sustainability of the many diverse and complex ecosystems upon which the military relies. Thanks to over three decades of comprehensive study and inventory of the plants and animals on military lands, we know now that many of those lands possess a remarkably high level of biological diversity. In many cases, military lands are more biologically diverse and provide more habitats to more threatened or sensitive species than public lands specifically managed for their biological values. Maintaining that level of biological diversity, which contributes to the ability of the land to withstand both natural and man-made disturbances, is critical to our national military preparedness.

The DoD has long recognized and complied with the requirements of a wide array of national environmental laws to protect its land, water and air resources and the organisms they support. Indeed, the department has become a leader in compliance with major natural resources laws such as the Endangered Species Act, the Clean Water Act, the Migratory Bird Treaty Act, and many others. Thanks to conducting extensive biological inventories of its lands, the DoD knows that its lands support the highest density of federally threatened, endangered, and sensitive species of any federal land management agency. Likewise, other analyses of DoD lands, typically performed by respected independent environmental groups such as The Nature Conservancy and NatureServe, have revealed that many of those lands represent some of the best-preserved natural landscapes in the country.

The outstanding condition of most DoD lands can be attributed to several factors, some more obvious than others. Among the most important is the comprehensive management approach the DoD has employed known as Integrated Natural Resources Management. This approach considers and coordinates all significant natural resources issues in a comprehensive planning document. Those issues range from considerations of the effects of military operations on soils, vegetation, wetlands, and species at risk, to strategies for the management of forestry, agricultural, and hunting and fishing programs. Key to the implementation of the

DoD's integrated natural resources program is the dedicated cadre of civilian and military natural resources managers whose job it is to ensure the accomplishment of the military mission in a way that sustains and enhances the natural resources on their installations. But their job can only be accomplished effectively by working in close cooperation with military operators whose support and understanding are critical to success.

The primary audience for which this handbook has been prepared are the DoD natural resources managers and military operators who use DoD lands for testing and training. However, as has been demonstrated with the earlier editions of this handbook, it is likely that land managers in other government agencies, environmental organizations, and interested private individuals will also find this resource valuable.

Building on the success of the 1996 and 2008 versions of this DoD Biodiversity Handbook, this updated version is intended to provide an overview of major DoD natural resources issues with a specific emphasis on biodiversity conservation.

Our goal is that all military and civilian DoD natural resources managers and operations personnel will refer to this revised DoD Biodiversity Conservation Handbook often. Its online format allows easy access to specific parts of interest. It should also be seen as a resource from which to draw for more specialized training.

It is our sincere wish that this updated resource will play an important role in helping the DoD maintain the long-term sustainability of the many complex ecosystems on which the military and our nation rely.

Part I. Introduction and Key Challenges

1. Meeting the Military Mission Through Conserving Biodiversity

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Introduction

Department of Defense (DoD) lands cover more than 25 million acres spanning a vast array of natural habitats, from Southwestern deserts and Hawaiian rainforest to high peaks in the Rockies and coastal marshes along the Gulf Coast. These ecologically diverse lands harbor an extraordinary array of plant and animal species, including nearly 490 federally listed endangered species and 550 at-risk species. This rich ecological fabric serves as an essential backdrop for high-quality and realistic military training and testing. Because of this, conserving biodiversity on DoD installations is key to maintaining readiness and meeting the military mission.

Biodiversity is a concept that, at its heart, can be understood as the *variety of life on Earth*. Although many people associate the term with the array of different species found in each place—or even just those that are threatened or endangered—the concept of biodiversity also includes the variety of ecosystems that occur across the landscape as well as the variation in genetic material found within species. Indeed, it is this breadth and inclusiveness—from genes to species to ecosystems, and from terrestrial and freshwater to marine systems—that makes biodiversity conservation so central to the work of DoD natural resource managers.

DoD has a long and successful history of managing natural resources on its lands to support military mission requirements and meet legal obligations. Natural resource management on DoD lands has evolved considerably over time, however, and since the early 1990s biodiversity conservation has been an overarching framework for DoD natural resource managers. This guide draws on that rich legacy of work and builds on two previous editions of *Conserving Biodiversity on Military Lands* (Leslie et al. 1996, Benton et al. 2008). Since the last edition of the guide, there have been numerous advances in techniques for understanding biodiversity—and the services it provides—as well as continuing progress in conservation strategies and planning approaches. There also have been new and emerging threats to species and ecosystems on military lands, including the spread of new wildlife diseases like white nose syndrome in bats. Of perhaps greatest concern is the increasingly evident and growing risks that a rapidly changing climate poses to DoD installations and their species, ecosystems, facilities, and other assets.

By providing a realistic backdrop for training and testing, healthy and well-managed natural ecosystems play an essential role in maintaining the readiness of military troops. Conversely, overuse and poor management can result in degraded ecosystems and declining species, which in turn can result in physical constraints as well as regulatory restrictions on the use of training and testing facilities. For this reason, the Sikes Act requires the development and implementation of *Integrated Natural Resources Management Plans* (INRMPs) for all U.S. installations with significant natural assets. By outlining the specific natural resource management goals for an installation, and charting a path for achieving those goals, INRMPs serve as the foundational documents for balancing trade-offs and ensuring the sustainability and resilience of the installation's ecological resources and support for the military mission.

This chapter introduces basic concepts regarding biodiversity and offers an overview of the condition and distribution of biodiversity across the United States, with a particular emphasis on military lands. The chapter also describes the evolution of DoD natural resource management over the years, including how installation managers have developed approaches for supporting the military mission while sustaining biodiversity.

Biodiversity: what is it?

Biodiversity, most simply put, is the variety of life on Earth—everything from genes, to species, to entire ecosystems. Shorthand for "biological diversity," the concept is most frequently applied to the array of plant and animal species that occur in a particular place, or region. The notion, however, captures not only the diversity of species in an area, but also the genetic variation within those species, as well as the organization of these species into biological communities and the variety of ecosystems across a landscape. Biodiversity conservation must take each of these levels into consideration.

As might be expected of a term that encompasses the vast array of life forms inhabiting the Earth, numerous definitions for biodiversity have been offered. Perhaps the most widely used definition is contained in the Convention on Biological Diversity, the international undertaking that grew out of the 1992 "Earth Summit" in Rio de Janeiro. The Convention defines biodiversity as:

…the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

Looking across the various definitions that have been proposed, four key concepts emerge that address different aspects of biodiversity: variety, variability, multiple biological levels, and sustaining processes.

- **Variety**. The number of different biological units of interest—for example, the number of distinct plants, animals, and microorganisms occurring on a particular installation, or the types of different ecosystems found across a state or region.

- **Variability**. The differences both within and among those biological units—for example, the genetic variation within a rare plant population, or the distinctions and differences found across the range of a widespread bird species.
- **Multiple biological levels**. The different levels of biological organization, including genetic, species, and ecosystem levels. The levels of this hierarchy are occasionally more finely subdivided, and landscape levels are often included.
- **Sustaining Processes**. The processes that sustain the variety and variability of life forms at these different biological levels. This can include ecological processes, such as the role of fire in maintaining many forest ecosystems, as well as evolutionary processes, such as the gene flow resulting from the dispersal of animals to other populations.

Another widely used framework for characterizing biodiversity distinguishes among three distinct components—composition, structure, and function—that apply at each of the biological levels (genes, species, ecosystems) described above (Noss 1990). In this framework, *composition* refers to the variety of different entities in a defined area, for example the identity and variety of species in a region, or the types of different ecosystems on an installation. *Structure* refers to the physical organization or pattern in a system, such as the vertical structuring of a vegetation type (e.g., grassland, shrubland, forest), the organization of populations or subpopulations across a species range, or the pattern of habitat patches across a landscape. *Function* includes ecological and evolutionary processes such as gene flow, pollination or seed dispersal syndromes, fire or flooding regimes, and energy and nutrient cycling in an ecosystem.

Consistent with these concepts, the DoD Conservation Instruction (DoDI 4715.03) defines biodiversity as:

The variety of life forms and the ecological processes that sustain it. Biodiversity includes the number and variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the ecological and evolutionary processes that keep them functioning...

The value of biodiversity and its services

Biodiversity in its fullest expression provides society with many benefits, direct and indirect. While some of these can be represented in dollars and cents, others cannot—at least not yet. Nonetheless, there is an increasing realization that biodiversity benefits not only our material well-being and livelihoods, but also contributes to security, health, and freedom of choices and actions. It is no coincidence that many of the regions around the world experiencing the greatest political and social unrest—and requiring the attention or intervention of U.S. military forces—are those where biodiversity and natural resources have been most severely depleted.

The value of biodiversity can be expressed from a variety of perspectives, ranging from scientific and economic to ethical and aesthetic. The Endangered Species Act includes a formal expression of this respect and value for biodiversity, noting that "…species of fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its People." And while the focus of the Act is on preventing the loss of species, the emphasis on ecosystems contained in the Act's purpose statement makes clear the connection to the broader concept of biodiversity: "…to provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved…" Other legal expressions of the value of biodiversity include the Clean Water Act's protections for wetland habitats, which are important not only for fish and wildlife, but benefit people through their role in regulating and purification of water supplies and reducing flood risks to communities and infrastructure.

Over the past two decades there has been an increasing recognition of the value of biodiversity to people through the provision of "ecosystem services" (MEA 2005, IPBES 2019). Indeed, assessing, quantifying, and valuing ecosystem services has been a major focus of research in recent years, including the benefits such services provide to DoD facilities and infrastructure (McDowell et al. 2020). Of particular importance is the protective benefit of "natural infrastructure," through reducing risks from natural hazards such as floods, wildfires, and landslides (Glick et al. 2020).

Drought and water security are critical concerns for many military installations, especially in the arid Southwest, and the role of biodiversity in regulating and sustaining water supplies is therefore of keen interest to DoD. Another ecosystem service of growing interest is the role of natural systems in climate protection, particularly the role that forests, grasslands, and other systems play in absorbing and storing carbon. The carbon sequestration potential of DoD's twenty-five million acres of land can be expected to be a component of any overall national approach to climate mitigation. Finally, there has been considerable work by the Army Corps of Engineers in recent years on engineering guidelines for the use of natural and nature-based features to reduce risks to built infrastructure (Bridges et al. 2015), as well as to more accurately estimate the value of natural infrastructure in required benefit-cost estimates.

Balancing mission and biodiversity at Fort Bragg

Set amidst the sandhills of North Carolina, Fort Bragg is one of the largest and busiest military installations in the world. The base, which is the home of the Army's airborne and special operations forces, trains more soldiers each year than any other military installation. The base plays a crucial role in enabling rapid deployments around the world, and soldiers from its 82nd Airborne Division must be ready to fight anyplace on the globe within eighteen hours. Military readiness is dependent on training, and training is a perishable commodity. As a result, Fort Bragg hosts extensive ground and aerial training exercises, and up to one hundred thousand parachutes a year blossom in the skies above the base. The success of these training maneuvers in meeting the military mission depends on the availability of adequate land and realistic fighting conditions.

Sharing the base's airspace and terrain with these parachutists are some of the last remaining red-cockaded woodpeckers (*Dryobates borealis*), a federally protected endangered species. Efforts to protect this seven-inch tall, black and white-striped woodpecker had the potential for dramatically restricting the training opportunities at the base with consequences for the installation's capacity for maintaining military readiness. Instead, by taking an innovative approach to managing the base's natural ecosystems and working across boundaries—geographic and institutional—Fort Bragg not only is helping ensure the survival and recovery of this endangered bird, but also is enhancing the availability of realistic training for the nation's troops. And in doing so, those involved helped forge a new generation of approaches for conserving biodiversity on military lands.

Longleaf Pine: a declining ecosystem

Longleaf pine (*Pinus palustris*) was once the dominant tree across much of the Southeast, and the ecosystem that bears its name covered on the order of ninety million acres. Over time, logging, land development, and other factors destroyed most of these old growth pine forests. By 2008, only about 3.4 million acres of this unique habitat existed, reflecting a 97 percent decline, and one of the most drastic reductions of any major natural ecosystem across the United States.

As the longleaf pine forests declined, so too did many of the species dependent on these habitats. Although some species are quite adaptable and able to survive equally well in one type of forest over another, others have highly specific requirements that tie them tightly to a particular habitat. Such is the case with the red-cockaded woodpecker. This species is the only woodpecker that creates cavities in live rather than dead trees, and these roosting and nesting cavities are located primarily in longleaf pines at least eighty years old.

In 1918, when Fort Bragg was created, longleaf pine was still widespread across the Southeast, and the area of North Carolina where the base was established was considered a remote and desolate region. Much has changed since that time, and as longleaf pine forests disappeared across most of their former range, the relative importance of remaining reservoirs of this habitat, such as Fort Bragg, increased. Of Fort Bragg's 161,000 acres, nearly half are covered with longleaf pine, representing one of the last strongholds for this disappearing ecosystem—and the red-cockaded woodpeckers that depend on them.

Jeopardy and beyond

Natural forests on the installation are important for providing a realistic training environment, and by maintaining the forest, base managers felt they were doing a good job of sustaining the red-cockaded woodpeckers. The U.S. Fish and Wildlife Service (FWS), which co-administers the Endangered Species Act, felt otherwise and in 1990 issued a "jeopardy opinion."[1] That regulatory opinion maintained that training activities on the base were having a detrimental impact on the long-term survival of the woodpeckers. As a result of this Fish and Wildlife Service order, a number of training restrictions were required to buffer the woodpeckers from training activities thought to be harmful, and in 1994 these restrictions were codified in management guidelines.

Restrictions on training activities at Fort Bragg and other Southeastern military installations provoked high-level consternation, including calls from some for congressional action. To defuse the situation, the Secretary of the Army and the Secretary of the Interior directed their respective staffs to work together and devise a strategy that would both support recovery of the woodpecker consistent with the Endangered Species Act and enable the Army to continue training its troops. A joint Department of Defense/Fish and Wildlife Service team was assembled under the leadership of a respected infantry officer and charged with tackling the issue.

What was needed to sustain and increase red-cockaded woodpecker numbers was already fairly well known to wildlife biologists and included a combination of proactive habitat management and creation of artificial nesting cavities. While a principal focus of the response to the jeopardy opinion was restrictions on training activities, the team recognized that a lack of proactive habitat management was probably the greatest factor limiting the bird's survival and recovery. By its regulatory nature, however, the Endangered Species Act is better suited to limiting potentially harmful activities than promoting beneficial ones, and the team was challenged to create a strategy that balanced these approaches.

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[1] When a federal agency seeks to take an action that might affect a listed species, it must send a "biological assessment" to one of the two Endangered Species Act administrator bodies. If the administrators feel the proposed action could put a listed species at risk of extinction, they can issue a "jeopardy opinion," which carries the force of a decision. For more on federal agency consultations under the Endangered Species Act, see https://www.fws.gov/endangered/what-we-do/consultations-overview.html.

Fortunately, the type of open understory forest habitat best suited for the woodpecker was also considered by military trainers to be an ideal cover type for providing realistic training experiences. This concordance in habitat opened up a host of opportunities for meeting mutual goals, and fire was key to maintaining suitable conditions for both. Healthy longleaf pine forests depend on frequent but low-intensity fires. As a result, prescribed burns are one of the key management tools for maintaining and restoring Fort Bragg's natural ecosystems, benefiting not only the woodpecker, but also a host of other rare species on the installation.

Mission critical thinking

The DoD/FWS team worked together to devise a novel strategy for ways in which Fort Bragg and other Southeastern military bases could contribute to regional recovery goals for the red-cockaded woodpecker. This approach started with understanding the amount of suitable or potentially suitable habitat on the installation, together with an identification of areas considered mission critical from a military training perspective. A specific and quantifiable "Mission Compatible Goal" would then be derived from these acreages, along with a more ambitious "Regional Recovery Goal," which could account for woodpecker clusters on adjacent lands. Proactive habitat management would be applied to all suitable or potentially suitable habitat, and artificial cavities created to help expand the number of woodpecker clusters, and increase the bird's population numbers.

New management guidelines based on this approach were adopted by the Army in 1996, and Fort Bragg was the first installation to implement an Endangered Species Management Plan under those guidelines. This set the stage for a substantial relaxation in training restrictions at the base. Experience developing and implementing those guidelines on Fort Bragg also informed an update and revision of the FWS recovery plan for the species, which was published in 2003.

With a growing number of woodpeckers using the base, the new management approach proved to be quite successful. In 2005, the population topped 350 clusters, a recovery goal that had not been expected for another several years. The increased numbers of woodpeckers on the base was sufficient to enable export of woodpeckers to properties off the installation to help in the overall regional recovery effort. Indeed, success in rebuilding red-cockaded woodpecker populations on Fort Bragg and other DoD installations in the Southeast helped set the stage for a FWS proposal in 2020 to downgrade the status of the species from "endangered" to "threatened" (FWS 2020).

Pressures from outside the gate

Even as Fort Bragg worked to reconcile red-cockaded woodpecker conservation and military training needs, it became apparent that a major threat to both loomed on the other side of the base fence. Rapid development of lands adjacent to the base was eliminating wildlife habitat and putting pressures on the base's lands. And the human occupants of the new developments increasingly were complaining about the noise and smoke associated with military training and testing exercises. These encroachment pressures demanded "outside-the-gate" thinking.

Historically, most military posts were established in remote areas where potential conflicts between local communities and military activities would be minimized. As many of these areas have become more densely populated, many active bases are in danger of becoming islands in an ocean of residential and commercial development, with consequences that can jeopardize the installation's primary missions. By the mid-1990s rapid urban development outside Fort Bragg was becoming increasingly worrisome to installation officials. Although housing and other developments being approved could have major impacts on the Army's ability to carry out maneuvers and other training activities, it had no jurisdiction over land use planning adjacent to the base. And as these adjacent lands were developed, the relative importance of Fort Bragg's lands for sustaining the red-cockaded woodpecker only increased.

Military planners recognized that a buffer of undeveloped land was needed surrounding the base both to meet red-cockaded woodpecker recovery goals, and for the training mission to be sustainable over the long term. At the time, however, there were few options available for the creation of such a protected buffer, and the Army had neither the authority nor the funds to purchase adjacent private lands for this purpose. Against this backdrop, officials at Fort Bragg began working with The Nature Conservancy to accomplish broader biodiversity conservation goals. Using the Sikes Act authority, in 1995 the Army entered into a cooperative agreement with The Nature Conservancy and the U.S. Fish and Wildlife Service to create the Fort Bragg Private Lands Initiative (PLI). This cooperative agreement and the resulting buffer lands initiative marked a major innovation and represented the first of its type within the military.

The encroachment issues experienced at Fort Bragg are being felt at installations across the country. Fort Bragg's Private Lands Initiative served as an early model for the creation of DoD programs specifically focused on preserving compatible land uses and natural habitats outside the installation fence line to provide a buffer for mission critical capabilities and operations. While authority for the Fort Bragg PLI was under the wildlife-oriented Sikes Act, the 2003 Defense Authorization Act affirmed and expanded authority for DoD to enter into partnerships with non-federal and private parties to address encroachment threats to military training, testing, and operations.[2] Taking advantage of that new authority (and subsequent enhancements), DoD has dramatically expanded its engagement in outside-the-

[2] Section 2811 of the 2003 Defense Authorization Act, codified at 10 USC 2684a.

fence habitat conservation and land use planning, especially through the Readiness and Environmental Protection Integration (REPI) program and associated Service-specific efforts, such as the Army Compatible Use Buffer (ACUB) program.

Lessons learned at Fort Bragg

Although Fort Bragg was an early leader in developing new approaches for balancing military training and biodiversity conservation, it is not unique. Creative and successful approaches to managing biodiversity on military lands are taking place across the country, and across all the military services. Common to many of these efforts are several success factors, which the Fort Bragg example highlights.

- Focus on the military mission: The underlying goal from the DoD perspective was to ensure the sustainability of Fort Bragg for carrying out critical training and testing activities and maintaining military readiness. Placing the conservation work in the context of military readiness enabled the Army to tackle these problems with characteristic intensity and efficiency.
- Think regionally and work across boundaries: Taking the broader landscape into account was important for understanding the role that the base's lands play in regional conservation issues, and conversely, the impact that off-installation land uses have on the base's ability to meet both military mission and conservation goals.
- Rely on the best available science: A deeper understanding of the status and needs of the woodpecker, its response to different training regimes, and the processes required to maintain and restore its habitat improved the effectiveness of management actions and allowed more flexibility in crafting approaches.
- Form partnerships and establish trust: Success required that individuals and organizations with different values and cultures establish working relationships based on trust. Establishing trust takes time and comes through each party gaining a better understanding of each other's goals, leading to mutual respect. Partnerships also allowed broader and deeper expertise to be brought to bear on the problem.

State of the nation: The condition of biodiversity across the United States

Stretching from the arctic of Alaska to the Florida Keys, and the coast of Maine to Hawai`i's volcanic islands, the United States supports an extraordinary diversity of life. Encompassing more than 3.5 million square miles of land and with 12,000 miles of coastline, the nation spans 120 degrees of longitude—nearly a third of the globe. This expanse includes an exceptional variety of terrains, from the Badwater Basin in Death Valley at 282 feet below sea level to the peak of Denali at 20,320 feet above.

The resulting range of climates has given rise to a wide array of ecosystems, from tundra and subarctic taiga to deserts, prairie, boreal forest, deciduous forests, temperate rain forests, and even tropical rain forests. Military installations are widely represented among these varied ecosystems.

This ecological tapestry sustains an equally remarkable array of species. Although the total number of species inhabiting America's lands and waters is far from fully known, an estimated 200,000 U.S. species have been formally described and named by science (Stein et al. 2000). Additional species continue to come to light as new areas are explored, and new and increasingly powerful scientific techniques for documenting diversity are developed. While many of these discoveries are among poorly known groups of organisms, such as insects and fungi, even among relatively well-known groups such as flowering plants up to thirty new North American species are described every year.

The U.S. military has played an important role in helping to discover and understand the nation's biological wealth. When Captain Meriwether Lewis of the First Infantry and Lieutenant William Clark set out in 1803 to cross the continent with their Corps of Discovery, they were under orders from President Thomas Jefferson to record everything they could about the countryside, including "the soils and face of the country, its growth and vegetation productions…the animals of the country...the remains and any which may be deemed rare or extinct." Many of western North America's most characteristic, and charismatic, wildlife species were first scientifically documented by the Corps of Discovery, including grizzly bear, pronghorn, and mule deer.

Lewis and Clark's journey was followed by other military expeditions exploring different routes across the continent, many of which included accomplished naturalists. The expeditions fueled the dramatic expansion in scientific knowledge about our flora and fauna that took place in the mid-1800s. A multitude of western plant and animal species have enshrined in their names the contributions of military men, such as Major John C. Frémont (*Fremontodendron californicum*, the California flannelbush), Major Howard Stansbury (*Uta stansburiana*, the western side-blotch lizard), and Captain John W. Gunnison (*Cynomys gunnisoni,* Gunnison prairie dog).

As exploration of the North American continent brought the nation into better focus, it became clear that the lands and waters harbored a spectacular assemblage of plants and animals. And while most people think of tropical rainforests as the region on earth teeming with the greatest diversity of life, for certain groups of organisms the United States is the global leader. For example, more salamander species are found in the United States than any other country on Earth, with the greatest concentrations of diversity in the Southeast. The United States is the global center of diversity for several other freshwater groups, including freshwater mussels and crayfishes. Among plants, the United States is second only to China in its variety of gymnosperms, a group that includes conifers like pines, firs, and spruces.

Hawai`i's inclusion in the United States, first as a territory in 1898 and later as a state in 1959, added tremendously to the richness of the nation's biological fabric. This set of mid-oceanic volcanic islands has never been connected to the mainland, and all life forms naturally occurring in the archipelago either arrived from elsewhere or evolved in place from earlier arrivals. The combination of isolation from other land masses, multiple islands within the archipelago, and the island's dramatic contrasts in terrain and climate—from tropical beaches to icy volcanic peaks—has led to perhaps the most distinctive and unique flora and fauna in the world. A species that is restricted to a specific area is referred to as *endemic* to that area, and Hawai`i has some of the highest levels of endemism in the world. More than two-fifths (43%) of Hawai`i's vertebrate animals are endemic, as are 87% of its vascular plants, and 97% of its insects (Stein et al. 2000). Not only are these species found just in Hawai`i, but many are extremely localized, a factor greatly contributing to the high levels of endangerment found in the Hawaiian flora and fauna, including on DoD installations.

How is America's biodiversity faring?

Broad concern about the decline of wildlife species began in the late 19th century, instigated in part by massive commercial slaughter of such species as the passenger pigeon, and the decimation of many waterbird colonies for plumes to adorn women's hats. These early concerns lead to such actions as the passage of the Lacey Act[3] in 1900 and establishment of the National Wildlife Refuge System in 1903. By the mid-20th century, it was apparent that many wildlife species were in decline from a variety of causes. This included the bald eagle, the nation's symbol, whose reproduction was plummeting due to pesticide-related thinning of its eggshells. As awareness of environmental problems increased, a host of seminal federal legislation was passed in the late 1960s and early 1970s, including the Clean Water Act, Clean Air Act, and National Environmental Policy Act (NEPA). The first endangered species protection act was adopted by Congress in 1966, and later replaced by the more expansive Endangered Species Act (ESA) of 1973.

Ensuring the continued survival of the nation's species requires that we have a sound understanding of how they are faring. That is, which species are widespread, abundant, and secure, and which are rare or declining, and at increased risk of extinction? Assessing a plant or animal's conservation status—or extinction risk—

[3] The Lacey Act of 1900 provided a variety of protections for flora and fauna. It prohibited game taken illegally in one state from being shipped across state boundaries contrary to the laws of the state where it was taken.

requires accurate information about the species' distribution, its population numbers, trends in those numbers, and any threats placing stress on those populations.

Endangered Species Act Listings

The FWS, which with the National Oceanic and Atmospheric Administration (NOAA) has primary responsibility for administration of the ESA, is charged with assessing the condition of plants and animals for the purpose of determining which warrant protection under that Act. For this purpose, the Service seeks to identify those species considered endangered, defined in the Act as "an animal or plant species in danger of extinction throughout all or a significant portion of its range," and those considered threatened, defined as "an animal or plant species likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

Overall, 1,666 U.S. species were listed under the Endangered Species Act as of December 2020, of which 1,273 are endangered, and another 393 threatened (FWS 2021b).[4] The number of listed species is dynamic, as additional species are considered for possible listing, and other species considered for delisting due either to recovery, extinction, or reassessment of their conservation status. For example, due to the elimination of the pesticide DDT and other conservation practices, bald eagle numbers in the lower 48 states have climbed from a low of 417 nesting pairs in 1963 to well over 10,000 pairs (FWS 2016). Based on this strong recovery, the species was removed ("delisted") from the federal endangered species list in 2007.[5] Species can also be "downlisted" from endangered to threatened in recognition of a sustained improvement in status or a decrease in threats. In October 2020, for example, the FWS proposed that red-cockaded woodpecker be reclassified from "endangered" to "threatened" in recognition of the substantial increase in populations resulting from conservation and species recovery work carried out by federal, state, and private partners, including DoD. In support of that proposal, the Service estimates that about 7,800 active clusters of red-cockaded woodpeckers now exist rangewide, up from about 4,700 active clusters in 1995 (FWS 2020).

The primary purpose of the endangered species list is to serve as the basis for legal protections and species recovery actions (see Table 1.1 for additional types of federally protected species). As Figure 1.1 shows, the rate of listings under the ESA varies dramatically, reflecting not only the biological condition of plants and animals, but also the availability of funds for listing and delisting activities, as well as shifts in

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[4] Of the 1,666 listed species, 445 are vertebrate animals, 278 invertebrate animals, and 943 plants.

[5] Bald eagle safeguards remain in place under the Bald and Golden Eagle Protection Act.

priorities and policies across administrations (Evans et al. 2016). As a result, the federal endangered species list is not a sufficient gauge of the overall condition of the U.S. biota. Indeed, a better overview of the broad condition of U.S. species is offered by the conservation status assessments of the NatureServe Network.

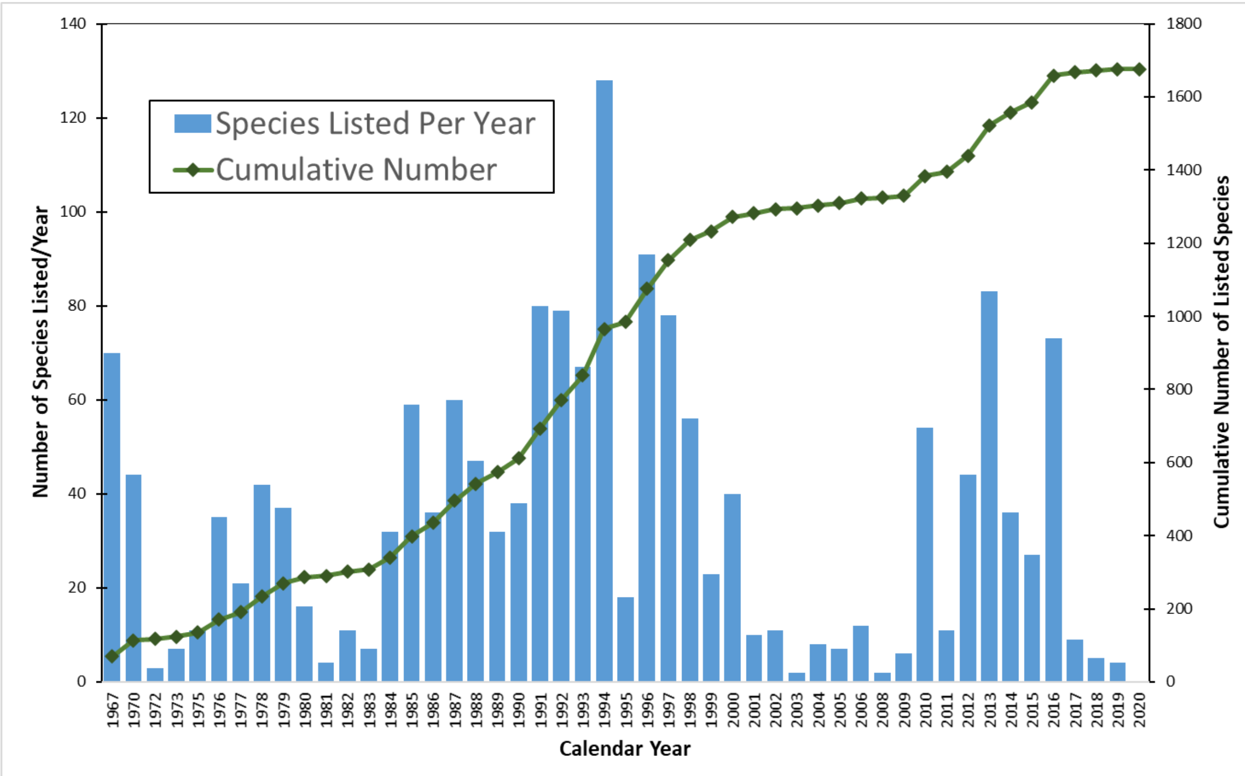

Figure 1.1. Listings under the U.S. Endangered Species Act. The rate at which species have been listed as threatened or endangered under the U.S. Endangered Species Act has varied considerably over time (FWS2021b).

Table 1.1. Federally protected species

Several federal laws provide legal protections for various U.S. species. In addition to these federal laws, many states have enacted their own endangered species and wildlife protection laws.

Law	Administering Agencies	Covered Species	Key Protections
Endangered Species Act of 1973	U.S. Fish and Wildlife Service and NOAA Fisheries Service	Listed Endangered and Threatened species. Species listed under the ESA include vertebrate animals, invertebrate animals, and plants	Prohibits the take of listed species, which includes to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect. Prohibits federal actions that are likely to jeopardize the continued existence of listed species or adversely modify designated critical habitats.
Marine Mammal Protection Act of 1972	NOAA Fisheries Service, U.S. Fish and Wildlife Service, and U.S. Marine Mammal Commission	Whales, dolphins, porpoises, seals, sea lions, walrus, polar bears, sea and marine otters, dugongs, and manatees	Prohibits the take of marine mammals, which includes harassment, hunting, capturing, collecting, or killing.
Migratory Bird Treaty Act	U.S. Fish and Wildlife Service	Migratory bird species that naturally occur in the United States or U.S. territories	Prohibits the take of protected migratory bird species, which includes killing, capturing, selling, trading, and transport.
Bald and Golden Eagle Protection Act	U.S. Fish and Wildlife Service	Bald eagles and golden eagles	Prohibits the take of bald or golden eagles, including their parts, nests, or eggs, which includes to possess, sell, purchase, barter, export or import.

NatureServe Conservation Status Assessments

NatureServe is a public-private partnership that serves as a clearinghouse for scientific information about the condition and location of the nation's species and ecosystems, with a particular focus on those that are rare or otherwise of conservation concern. NatureServe in collaboration with its network programs operating across North America including in each U.S. state (NatureServe Network) assess the conservation status of species based on about a dozen factors that relate to increases in extinction risk. These assessments are designed to categorize species into one of five "conservation status ranks," ranging from critically imperiled

(G1) to secure (G5) (Table 1.2).[6] Because the status of species may vary from place to place, assessments are carried out at a rangewide scale (where "G" indicates global), as well as at the state level (where "S" indicates state or subnational). As an example, the red-cockaded woodpecker is categorized as vulnerable (G3) across its entire range, which stretches from Texas to Maryland. Its status in any particular state, however, may differ from that rangewide status. In North Carolina, for instance, the woodpecker is regarded as imperiled (S2), while in Virginia it is ranked as critically imperiled (S1). Combining rangewide and state-level conservation status ranks offers a powerful tool for placing local conservation priorities into a broader national and global context.

Table 1.2. NatureServe conservation status ranks

Status	Rank	Definition
Presumed Extinct	GX	Not located despite intensive searches and virtually no likelihood of rediscovery.
Possibly Extinct	GH	Missing; known from only historical occurrences but still some hope of rediscovery.
Critically Imperiled	G1	At very high risk of extinction due to extreme rarity (often 5 or fewer populations), very steep declines, or other factors.
Imperiled	G2	At high risk of extinction due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors.
Vulnerable	G3	At moderate risk of extinction due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors.
Apparently Secure	G4	Uncommon but not rare; some cause for long-term concern due to declines or other factors.
Secure	G5	Common; widespread and abundant.

Note: NatureServe assesses status at three geographic levels: "G" indicates global or rangewide; "N" refers to national, and "S" denotes subnational (state or province). For additional information on these status ranks, see https://explorer.natureserve.org/AboutTheData/Statuses.

By assessing the conservation status of every species in the best-known groups of plants and animals, the NatureServe Network has been able to create a comprehensive view of the overall condition of the U.S. flora and fauna. Summarizing status information across 19 plant and animal groups, representing 27,784 individual species, indicates that more than one-third (33.6%) of U.S. species display some level of increased extinction risk (G1 - G3) (Figure 1.2). Of particular concern are the approximately 9% regarded as critically imperiled (G1) and 10% categorized as imperiled (G2). Looking at conservation status across the various

[6] For a full explanation of NatureServe's conservation status ranking system, see https://explorer.natureserve.org/AboutTheData/Statuses.

groups of plants and animals reveals some striking patterns (Figure 1.3). While considerable conservation attention focuses on the plight of rare birds and mammals, these groups actually have relatively modest levels of imperilment when compared with several of the taxonomic groups dependent on freshwater habitats. Indeed, 76% of freshwater snail species and 65% of freshwater mussels are categorized as vulnerable, imperiled, or already extinct. Flowering plants, however, contain by far the largest number of at-risk species, due both to the large number of species in this group overall (more than 16,000 native species), and the many rare and highly localized plants that occur in different regions.

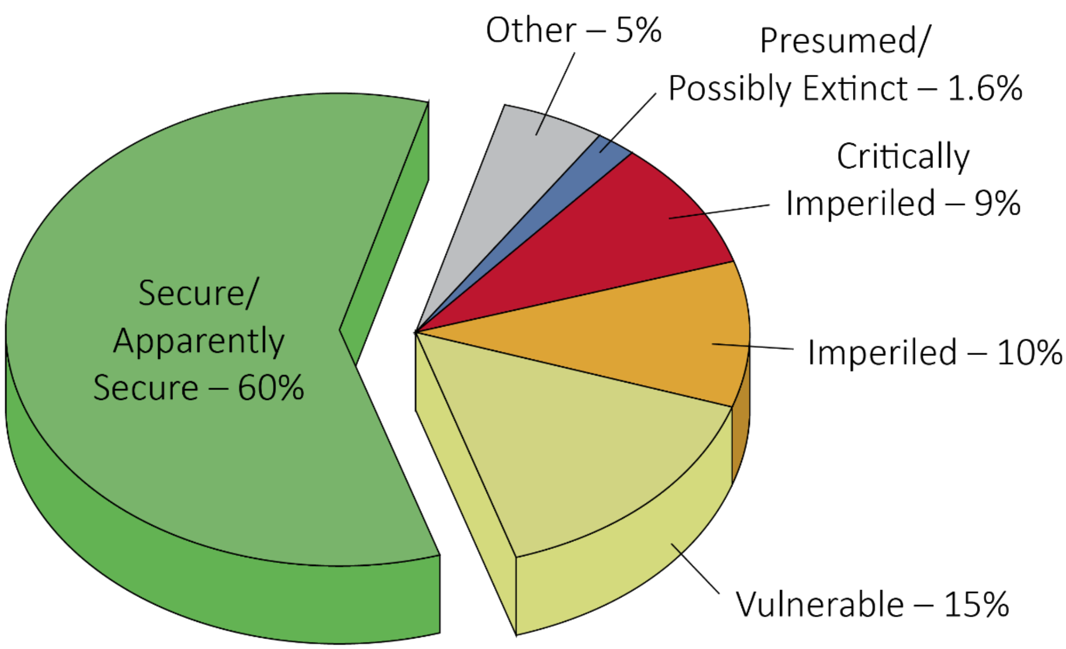

Figure 1.2. Proportion of U.S. species at elevated risk of extinction. About one-third of U.S. species in taxonomic groups comprehensively assessed by the NatureServe Network exhibit elevated levels of extinction risk (G1 - G3). (Source: NatureServe Network 2021).

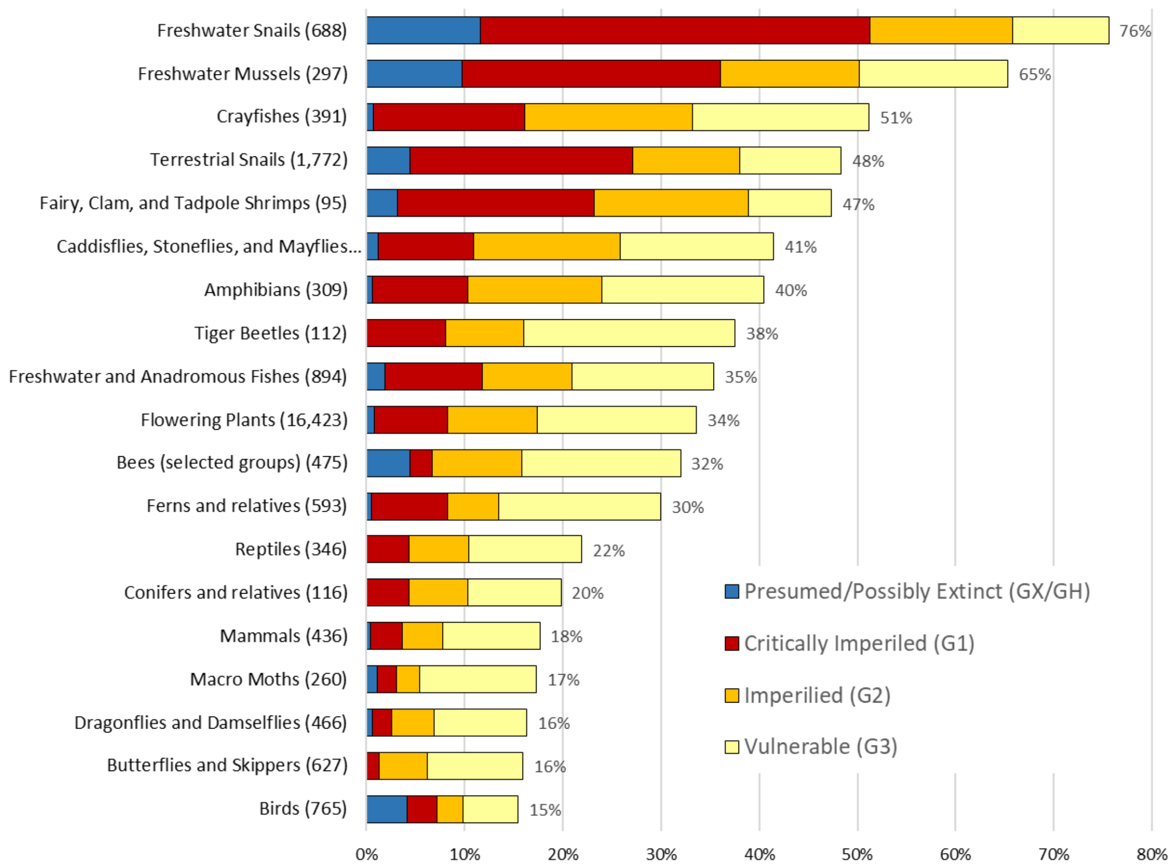

Figure 1.3. Conservation status by plant and animal group. Levels of extinction risk vary dramatically among different groups of plants and animals. Numbers (at left of bars) indicate the number of U.S. native species in the taxonomic group while percentages (at right of bars) reflect the proportion that are at risk of extinction (G1 – G3) or already extinct (GX/GH). In general, species groups that rely on aquatic habitats—such as freshwater snails, mussels, and crayfishes—are faring the worst (Source: NatureServe 2021).

At least 173 U.S. species have already been lost to extinction and are categorized by the NatureServe Network as “presumed extinct” (GX) (NatureServe 2021).[7] This includes species that were once extremely abundant, such as the passenger pigeon and Carolina parakeet, along with more obscure organisms, like the San Nicolas Island boxthorn (*Lycium verrucosum*), previously known only from an island that is now part of Naval Base Ventura County. Definitively establishing that a species has gone extinct is a difficult proposition since one must, of necessity, rely on the

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[7] As of December 2020. For a recent review of North American plant extinctions, see Knapp et al. 2021.

absence of evidence—which, as former Defense Secretary Donald Rumsfeld famously pointed out, is not the same thing as evidence of absence. As a result, at least 431 U.S. species are categorized by the NatureServe Network as possibly extinct (GH) (NatureServe 2021); most of these species have not been seen in many years and are regarded as “missing in action.”

Species of Greatest Conservation Need

One additional set of species that have been designated as having conservation significance are the “species of greatest conservation need” (SGCN) identified in State and Tribal Wildlife Action Plans. Congress created the State Wildlife Grant program in 2000 to help state fish and wildlife agencies and their partners conserve sensitive or imperiled fish and wildlife species, especially those not traditionally hunted or fished. A cornerstone of each plan is the identification of species of greatest conservation need. These lists are intended to identify those species in a state that are rare or declining, which then serve as the basis for the plan’s conservation actions and implementation. Because there is no specific guidance on how states should evaluate and identify these species, there is a high degree of variability from one state to another in number and types of species designated as SGCNs. Based on the most recent (2015) wildlife action plans, approximately 12,000 species and subspecies were collectively designated as SGCNs. This includes 11,133 species and 1,370 infraspecific taxa (subspecies and varieties) (USGS 2017).[8] Among those species, 22% are vertebrate animals, 45% are invertebrates, and 32% are plants.

A Geography of Imperilment

As any outdoors lover knows, wildlife are not distributed uniformly across the landscape, but individual species have very particular habitat needs. Climate is the principal determinant of a region’s flora and fauna: Palm trees don’t grow outdoors in Alaska, nor do caribou wander around Florida. Although as a rule, the diversity of species increases as one moves south towards the equator, the natural diversity of species in any given region is dependent on a host of factors. These include the complexity of terrain, type of soils, interconnections with other regions, and even the lingering effects of Pleistocene glaciers. The states with the greatest number of species are for the most part clustered along the nation’s southern edge (Figure 1.4). The top-ranking states for total number of species are California and Texas followed by Arizona, Alabama, Georgia, and North Carolina (NatureServe 2021). Looking instead at the levels of risk (that is, the proportion of a state’s species that are vulnerable, imperiled, or extinct), Hawai`i and California dominate all others

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[8] Another 413 higher taxa (genus and above) were also designated as SGCNs including an unknown number of species.

(Figure 1.5). Indeed, an extraordinary 83 percent of Hawai`i's native species are at increased risk of extinction (NatureServe Network 2021).

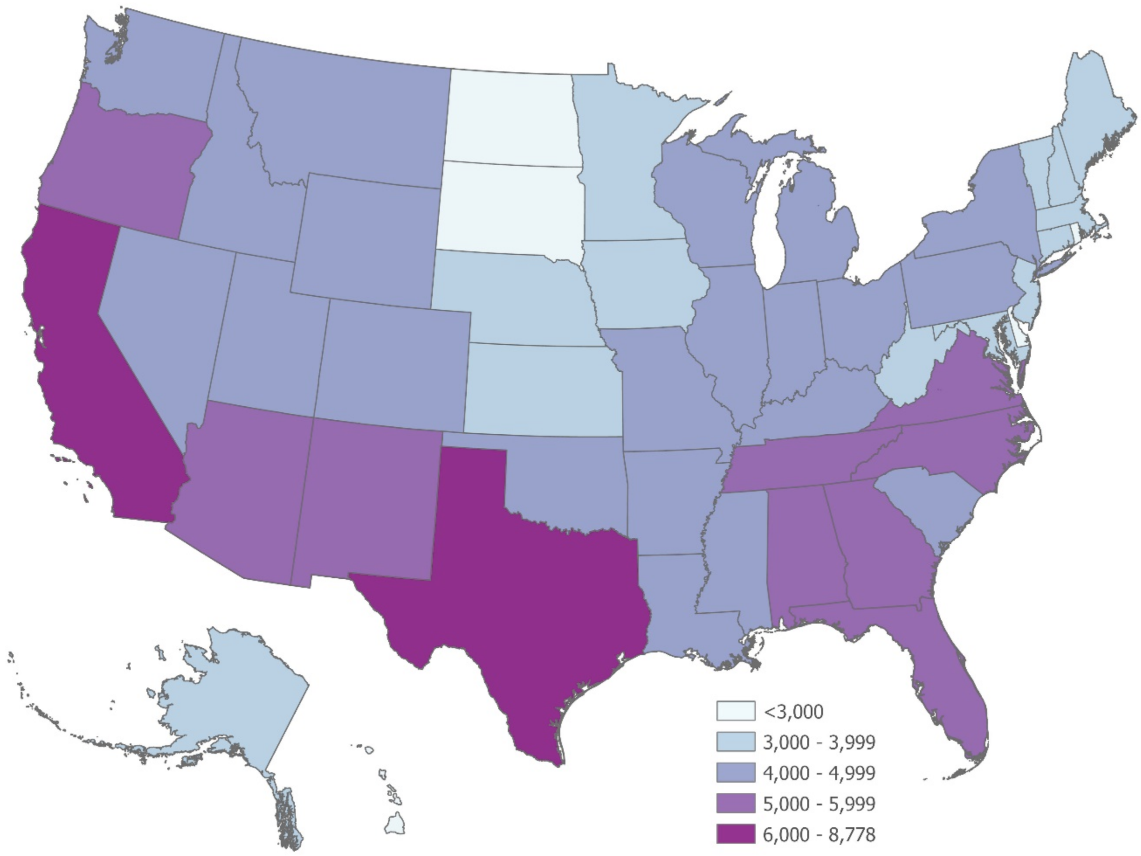

Figure 1.4. Species diversity by state. This map represents the number of species in each state for taxonomic groups comprehensively assessed by the NatureServe Network (see Fig. 1.3). Species diversity— or richness—is highest along the Pacific Coast, and more generally along the nation's southern edge. (Source: NatureServe Network 2021).

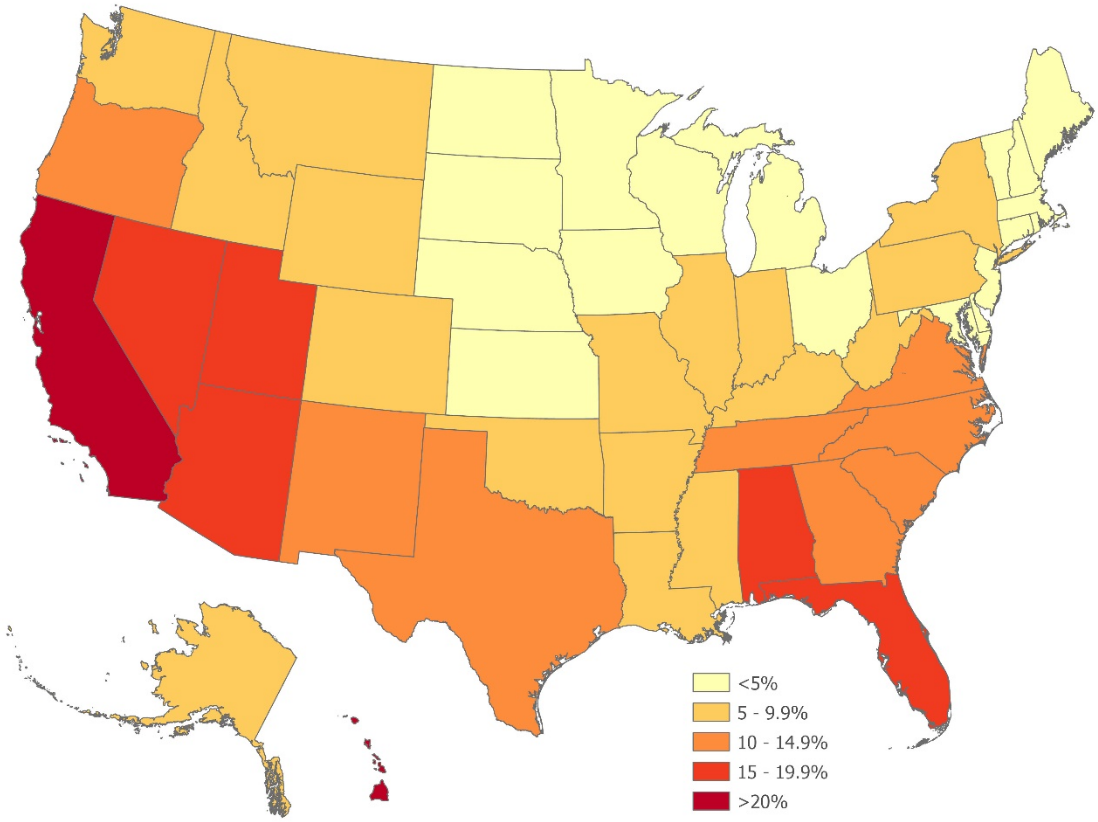

Figure 1.5. State patterns of risk. This map displays the percent of species with elevated risk levels (GH - G3) for taxonomic groups comprehensively assessed by the NatureServe Network (see Figure 1.3). Hawai'i displays by far the highest levels of extinction risk among its species, followed by California (Source: NatureServe Network 2021).

NatureServe Network Programs maintain databases of precise locational data for most rare and endangered species, representing a valuable resource for military planners and resource managers. Because these state-managed data are developed and maintained according to nationally consistent standards developed by the NatureServe, they can be pulled together to provide a far more fine-grained view of the geography of imperilment across America. Mapping the number of imperiled species (G1 and G2) against an equal area grid (Figure 1.5) provides a striking depiction of where these very rare and often localized plants and animals are concentrated. Of particular note are the imperiled species concentrations apparent throughout Hawai`i, in many parts of California, in the central Appalachians, across the panhandle of Florida, and along the central ridge of Florida. Even a casual perusal of this map suggests a considerable overlap between this geography of imperilment and the location of many of the military's landholdings, a topic that will be more fully explored in a later section.

Causes of Declines

Although there are many causes for declines in U.S. species, two in particular stand out. These are the loss or degradation of natural habitats and the introduction and spread of non-native species. Poised to eclipse even these, however, is the rapid acceleration of climatic changes, which already is beginning to cause disruptions and transformations of natural ecosystems and declines in native species (Staudinger et al. 2013).

Habitat loss

The natural complexion of the North American continent has changed dramatically in the time since European colonization. Although scholars now recognize that Native Americans extensively managed and manipulated their environment, the extent and condition of major habitats at that time serves as a useful baseline for measuring change. The production of food, fuel, and fiber, and the construction of housing and other infrastructure has consumed vast areas of natural habitat. While much of this conversion is old news, the loss of natural habitat and other types of open space continue. For example, between 1990 and 2000 an estimated 3.5 million acres of open space was lost to urban development across the country (McDonald et al. 2010). Considering all forms of conversion and human modification, an estimated 24 million acres of natural area was lost to development between 2001 and 2017 (CSP 2019).

Some natural ecosystems have been particularly affected by habitat loss and degradation. Taking advantage of the rich soils of the Midwest, agriculture has replaced more than 98 percent of the original tall-grass prairie, matching the level of loss to the longleaf pine forests of the Southeast. Wetlands play a particularly important role in providing fish and wildlife habitat and maintaining clean water, yet more than half (53 percent) of wetlands across the lower 48 states have been destroyed (Dahl 1990). Despite protections under the Clean Water Act, wetlands continue to disappear, and an additional 62,300 acres of wetlands were lost between 2004 and 2009 (Dahl 2011).

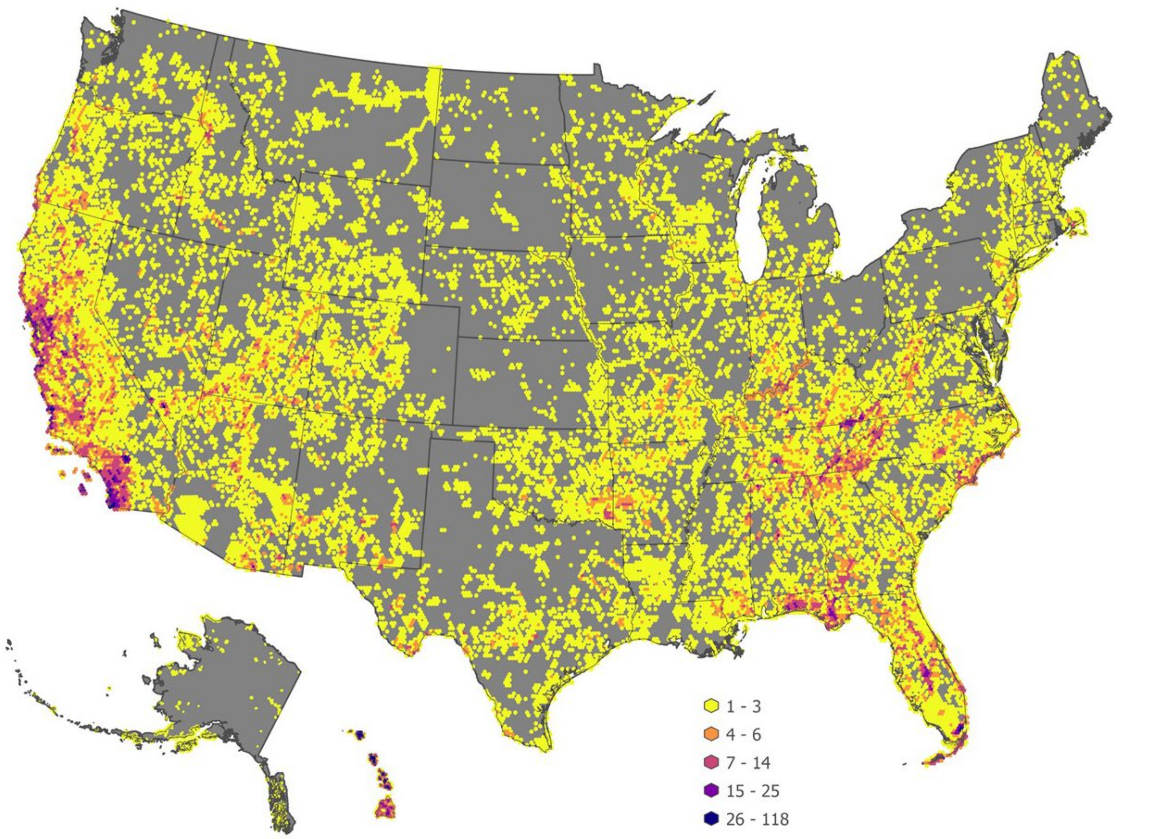

Figure 1.6. Distribution of imperiled species in the US. Mapping the number of imperiled species (G1 or G2) across the nation using an equal-area grid (hexagons = 49 square miles) highlights the biological importance of regions such as Hawai'i, coastal California, the panhandle and central ridge of Florida, and the southern Appalachians (Source: NatureServe Network 2021).

Invasive species

The introduction and spread of invasive species is another major driver of species decline and ecosystem disruption. Invasive species are defined as non-native organisms whose introduction causes, or is likely to cause, economic or environmental harm, or harm to human, animal, or plant health. There are several mechanisms by which invasive species cause harm to native biodiversity, ranging from direct predation, competition for resources, and hybridization with native species to alteration of key ecosystem functions and structure. As an example, nutria (a large South American rodent) accelerates erosion and loss of wetlands through its burrowing activities, while cheat grass in the intermountain West is fueling loss of sagebrush habitat by altering natural fire regimes. Invasive species have been identified as the second leading threat to endangered species in the United States (Wilcove et al. 1998).

Climate change

Rapid climatic changes are emerging as a major threat to native species and ecosystems in the United States. Temperatures across the United States have already increased an average of 1.8°F, with Alaska warming at nearly twice the rate of the lower 48 states (USGCRP 2017). The decade 2010-2020 was the hottest in recorded history, and the five warmest years on record all have occurred since 2015 (NOAA 2020). Beyond an increase in average temperature, however, several other climate-related factors are of ecological significance, including changes in precipitation patterns (longer and more severe droughts, more intense rainfall events), more powerful storms and hurricanes, longer and more frequent heat waves, melting of permafrost, and rising sea levels. Changing climatic factors in turn have cascading ecological impacts, which include shifts in the distributional range of plant and animal species, shifts in breeding seasons and other lifecycle events including migrations, and disruption of interactions among interdependent species (e.g., pollinators) (Staudinger et al. 2013). Climate-related impacts are also being documented at the ecosystem level, with changes occurring in the species composition of many habitats, in ecosystem processes, such as water and nutrient cycling, and even in the structure of the ecosystem, such as conversion of forest to shrub or grassland (Grimm et al. 2013).

Several species already have been listed under the Endangered Species Act primarily as a result of climate change-related threats, including polar bear (*Ursus maritimus*), bearded seal (*Erignathus barbatus*), and several species of coral (e.g., *Acropora palmata* and *A. cervicornis*). Many other federally listed species are regarded as sensitive to climate change (Delach et al. 2019), complicating their recovery prospects, and numerous other species are considered climate-vulnerable and could experience declines to a level where ESA protections may be warranted. Rapid and accelerating climatic change increasingly is becoming a defining concern for biodiversity conservation and wildlife management (Stein et al. 2013, Inkley and Stein 2020).

Biodiversity on military lands

The implications for DoD of long-term biodiversity declines and loss of habitat are vividly illustrated by Marine Corps Base Camp Pendleton, which is situated along the rugged coast of southern California. Home to the I Marine Expeditionary Force, Camp Pendleton is the only west coast amphibious assault training center and stretches along 17 miles of undeveloped coastline. The installation has become something of an island of natural habitat in a sea of urbanization, and now harbors the largest contiguous stands of coastal sage scrub in the San Diego region.

Coastal sage scrub is an aromatic habitat that once covered many of the seaside hills stretching south from Los Angeles to San Diego. As one housing development after another has been built in the hills overlooking the Pacific Ocean, much of this unique habitat has been lost one piece at a time. Over the years, the cumulative effect of these piecemeal land use decisions resulted in the loss of much of the original coastal sage scrub, with the result that several species dependent on this habitat type have declined significantly. Among these is the coastal California gnatcatcher *(Polioptila californica californica)*, a diminutive bird whose population declines led to its federal listing as threatened in 1993.

Camp Pendleton is situated within one of the nation's most intense biodiversity hot spots (Figure 1.5). Not surprisingly, a considerable number of rare and endangered species are found on the base, including at least 18 federally listed species. And as natural lands disappear elsewhere in coastal California, the importance of the base's habitats for sustaining the region's rich and threatened biodiversity increases. But Camp Pendleton is just one of many DoD installations that play an important role in maintaining biodiversity across the United States.

Lands managed by DoD cover about twenty-five million acres across the nation, and span a wide array of different ecosystems, representing many of the major land and climate types in which soldiers may be expected to fight (Doe et al. 1999). This includes harsh desert terrains like the Yuma Proving Ground, mountainous regions like Colorado's Fort Carson, and balmy barrier islands as at Florida's Eglin Air Force Base. Many of these lands were designated for military use long ago and situated in some of the premier wildlands across the country. And because a primary mission for most of these bases is training troops in realistic outdoor settings, they often contain excellent examples of their region's wildlife habitat. The military has made a serious commitment to understanding and documenting the wildlife, including rare and endangered species, that are found on its lands, as a means both to comply with environmental regulations and to work proactively to sustain its resource base.

Federally listed species on DoD lands

As of 2020, there were 487 federally listed threatened and endangered species reported to occur on DoD lands (DoD 2020a). One way to put the role of military lands for maintaining biodiversity into context is to compare the number of endangered or at-risk species found on defense lands with those of other federal agencies. Several studies have documented particularly high levels of endangered species on DoD lands relative to other federal agencies (Flather et al. 1994, Groves et al. 2000, Stein et al. 2008). Based on the most recent such analysis (Stein et al. 2008), the 25 million acres of DoD lands harbor about the same number of federally listed species as the 193 million acres of lands managed by the U.S. Forest Service (Figure 1.6). The significance of military lands for biodiversity is therefore particularly striking when viewed from the perspective of the density of listed species per million acres (Figure 1.7). Federally listed species are only a portion of the total number of plants and animals that are at increased risk of extinction and of conservation concern. Considering instead the number of NatureServe-defined critically imperiled (G1) and imperiled (G2) species, in 2008 military lands were recorded as having about 460 such species, ranking third in number of imperiled species behind the Forest Service and the Bureau of Land Management (BLM). Looking across the military services (Figure 1.8), Army bases were recorded as having the largest number of both listed and imperiled species.

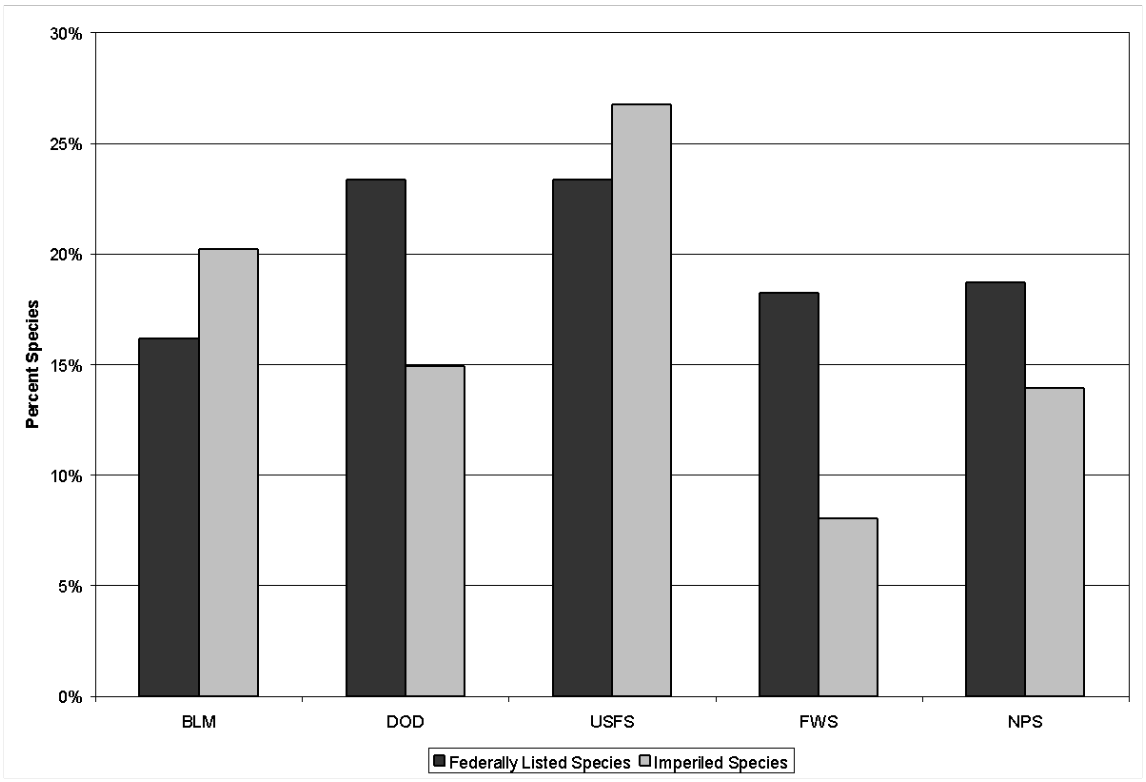

Figure 1.7. Endangered and imperiled species on federal agency lands. Lands of the DoD and U.S. Forest Service harbor the greatest number of species with formal status under the Endangered Species Act (Adapted from Stein et al. 2008).

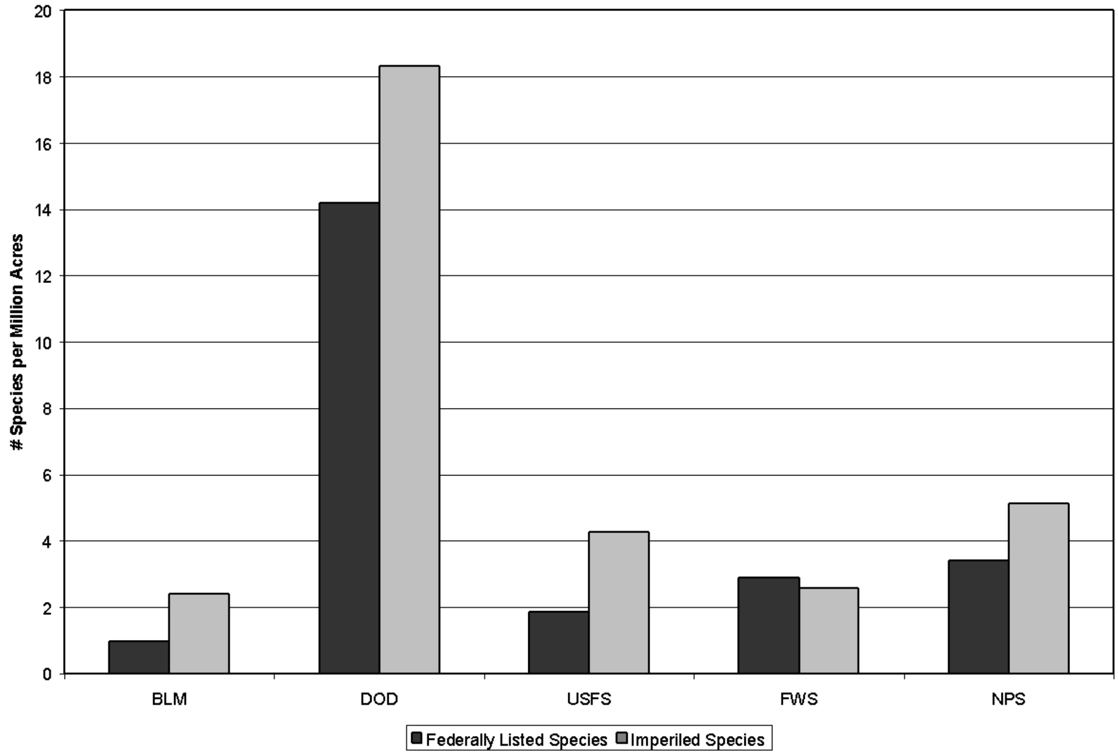

Figure 1.8. Density of endangered and imperiled species on federal lands. Military lands have the greatest density of both ESA status species and imperiled species of any federal land management agency (Adapted from Stein et al. 2008).

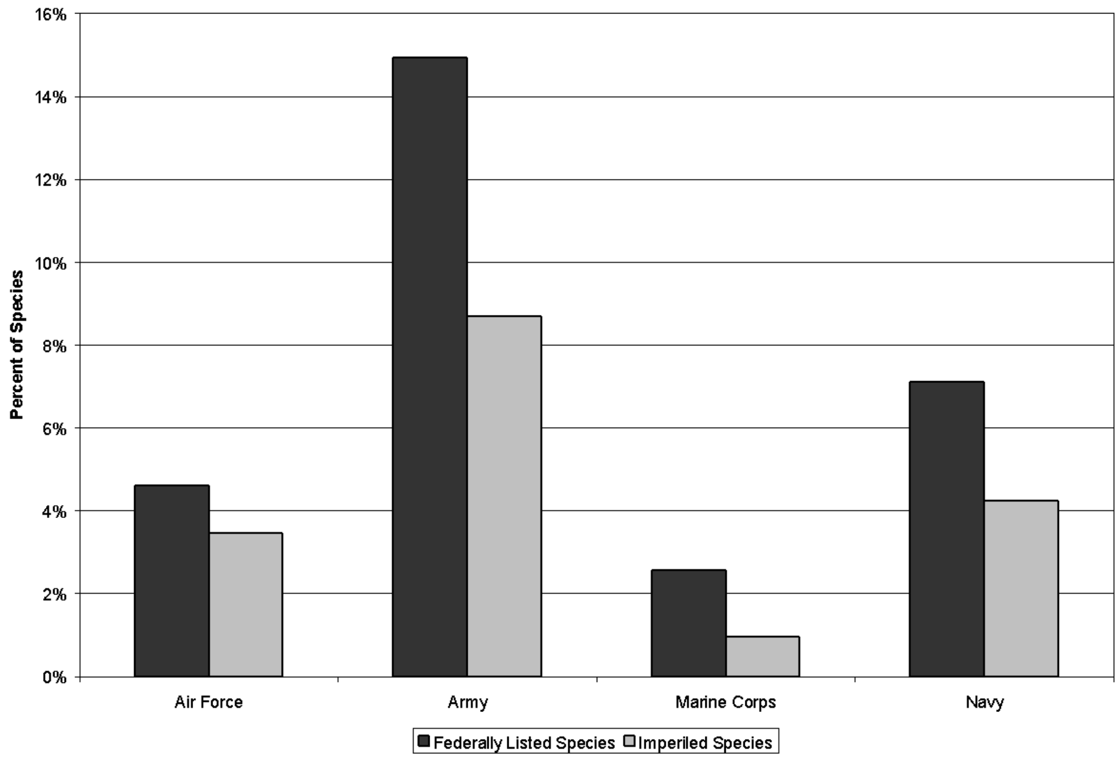

Figure 1.9. Endangered and imperiled species by military service. Army lands support the largest number of both ESA status and imperiled species (Adapted from Stein et al. 2008).

The top ten military installations for federally listed species reflect the overall patterns of biodiversity described earlier, with bases in Hawai`i, California, and Florida well represented (Table 1.3). Four of the top five bases are in Hawai`i—Schofield Barracks Military Reservation, Makua Military Reservation, Joint Base Pearl Harbor-Hickam, and Kawailoa Training Area—highlighting the extreme levels of endemism and risk associated with the native Hawaiian biota. Indeed, the military's Hawaiian holdings clearly are a major factor in defining the overall number of listed species on DoD lands. The DoD has more discrete land holdings in Hawai`i than any other federal agency, and although many are fairly small, as a whole they touch upon a wide variety of biologically distinctive zones, each of which has its own distinct assemblage of rare species, including many rare and endangered plants.

Table 1.3. Top ten military installations for federally listed species

The top installations for federally listed species illustrate the biological significance of bases in Hawai'i, Guam, Florida, and California. Number of species are based on installation self-reporting as of FY2019 (DoD 2020a).

Service	Installation	# Species

Army	Schofield Barracks Military Reservation, HI	58
Army	Makua Military Reservation, HI	46
Navy	Joint Base Pearl Harbor-Hickam, HI	41
Army	Kawailoa Training Area, HI	33
Navy	Joint Base Marianas, Guam	32
Army	Pohakuloa Training Area, HI	26
USAF	Homestead Air Reserve Base, FL	25
USAF	Vandenberg Air Force Base, CA	23
USAF	Cape Canaveral Air Force Station, FL	21
USMC	Marine Corps Base Camp Pendleton, CA	18

Species at risk on DoD lands

Proactive conservation of unlisted but imperiled species on and around DoD installations can help preclude the need for federal listing under the Endangered Species Act. For this reason, DoD has commissioned studies to document what at risk-species occur on or adjacent to military lands in order to better target such proactive conservation efforts (Benton 2004, NatureServe 2011, NatureServe 2015). In the most recent (2015) analysis, for DoD purposes "species at risk" are defined as plant and animal species not federally listed as threatened or endangered under the Endangered Species Act, but that are either: federally designated as proposed or candidates for listing; assessed by the NatureServe Network as critically imperiled or imperiled (G1 or G2) throughout their range; or are birds with a NatureServe global rank of vulnerable (G3) or an IUCN conservation status rank of threatened (CR, EN, or VU) or near-threatened (NT).[9] The most recent survey found that 555 such at-risk species occurred on or near DoD installations, of which 7% were federal candidates, 27% were critically imperiled, 62% imperiled, and 4% vulnerable birds (NatureServe 2015).[10] Of these, 74 species are restricted (or mostly so) to DoD lands. The highest number of at-risk species were found on Eglin Air Force Base (FL), Schofield Barracks (HI), and Makua Military Reserve (HI), all of which have more than 25 at-risk species (Fig. 1.10).

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[9] The International Union for Conservation of Nature (IUCN) Red List of Threatened Species (www.redlist.org) uses an extinction risk assessment process similar to NatureServe's global ranks.

[10] Excluding bird species included solely based on IUCN status, the total number of species at risk on DoD installations is 531 (NatureServe 2015).

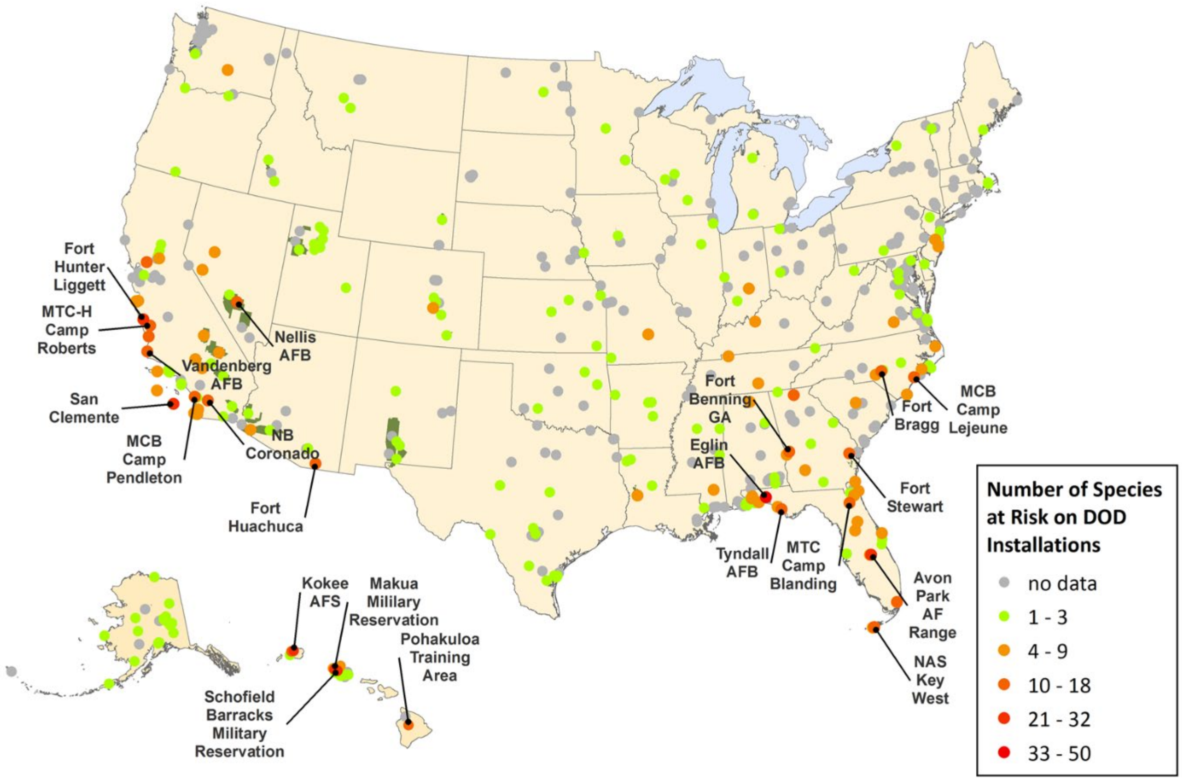

Figure 1.10. Species at risk on or near DoD installations. Based on 2014 data, the highest numbers of DoD-defined species at risk were found on Eglin Air Force Base (FL), Schofield Barracks (HI), and Makua Military Reserve (HI): Each of these installations has more than 25 at-risk species (Adapted from NatureServe 2015).

Evolving approaches to military natural resource management

The military is justifiably proud of its tradition of natural resource stewardship. The armed forces have been called upon to oversee or manage public lands and natural resources since 1823, when timber and forest products used in shipbuilding were strategic resources (Siehl 1991). Before there was a U.S. Forest Service or a National Park Service, the cavalry and engineers of the U.S. Army managed the lands set aside as national parks. Over the past several decades the military has strengthened its commitment to natural resource management, responding to new challenges and incorporating new scientific and technological advances. This has led to, among other things, adopting the principles of ecosystem-based management and adaptive management, and most recently the practice of climate change adaptation and resilience.

With the outbreak of World War II, millions of acres were acquired by the military to house, train, and prepare troops for combat. Construction practices, training exercises, and tank traffic lead to serious environmental problems at many sites, including dust, mud, and erosion. In those years, the military largely attempted to address these issues through cooperative agreements with the Soil Conservation Service[11] and transfers of agronomists and foresters to military installations. Following the war, natural resource management progressed to include planting of ground cover crops and trees, while timber production, agricultural leasing, and hunting programs were put in place at many installations.

By the 1960s, there was a general shift in public policy toward “multiple use” of public lands and management for “sustained yield.” This trend, in conjunction with declining military funding and increasing public pressure for access to military lands for recreation and commercial purposes, shaped natural resource management on military lands. Passage of the Sikes Act in 1960 provided the legal basis for wildlife conservation and public access for recreation on military land and authorized the collection of fees and the development of cooperative plans by the military, the U.S. Fish and Wildlife Service, and state fish and game agencies. During this period, however, policies generally encouraged consumptive uses of natural resources, and the revenues generated from forestry and fish and wildlife programs became the major source of funding for installation natural resource management programs (Lillie and Ripley 1998).

The 1970s and 1980s were decades of increasing pressure on natural resource management programs. The National Environmental Policy Act, the Endangered Species Act, and a host of other environmental protection statutes added demanding new requirements. The development of new weapons systems, which involved heavier vehicles and longer-range weapons, intensified damage and increased the military’s need for additional and diversified training lands. With federal and state regulatory agencies emphasizing environmental cleanup and waste management, there was little institutional incentive to increase either staffing or funding for natural and cultural resources programs (Lang and Lillie 1995). Natural resource management programs continued to focus on game and revenue generating programs, such as agriculture, grazing, timber, and recreational hunting and fishing. It became increasingly clear, though, that the military was facing natural resource management challenges it was not well equipped to address. Poor management was leading to the loss of training lands, while compliance with environmental statutes such as the Endangered Species Act and Marine Mammal Act was becoming an increasing burden on military operations.

In 1982 the scope of the Sikes Act was expanded beyond fish and game to include ESA-listed threatened and endangered species, while in 1986 a requirement was added to employ professionally trained natural resource professionals and to have

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[11] Now known as the USDA Natural Resources Conservation Service.

cooperatively developed fish and wildlife plans reviewed at least every five years. In 1997 the Sikes Act was amended to require that each installation with significant natural resources prepare and implement an Integrated Natural Resources Management Plan (INRMP) reflecting the mutual agreement of DoD, U.S. Fish and Wildlife Service, and the relevant state wildlife agencies. These plans, which are required on about 340 installations, are intended to help balance competing interests in the management of land, forest, wetlands, and wildlife habitat, and to the extent practicable provide for no net loss in the capability of installation lands to support the military mission. In recognition of the federal and state coordination requirements embodied in INRMPs, in 2003 Congress exempted DoD lands from critical habitat designations under the Endangered Species Act, provided that the lands are covered by an INRMP that offers a conservation benefit to the listed species.

A shift toward ecosystem management and biodiversity conservation

In the 1990s, federal land management underwent a profound shift with the emergence and adoption of ecosystem-based management and biodiversity conservation as overarching philosophies. Ecosystem management contrasts with the single-resource management approaches that were prevalent until that time. Instead, an ecosystem-based approach focuses on management of complex systems by addressing underlying processes while taking into consideration not only ecological, but also economic, and social concerns. DoD's adoption of this approach was reflected in a seminal 1994 DoD policy directive on ecosystem management, which was subsequently incorporated into the 1996 update of the DoD Conservation Instruction (DoDI 4715.3).

Biodiversity conservation

The year 1995 marked a milestone in the military's efforts to develop an overall strategy for managing biodiversity on military lands. At the direction of the Deputy Under Secretary of Defense (Environmental Security), a national dialogue was held under the auspices of the non-profit Keystone Center, which brought DoD officials together with representatives of other government agencies and nongovernmental interests. The purpose of this dialogue was to develop policy guidance for enhancing and protecting biodiversity on DoD lands in a way that is integrated with the military mission.

The Keystone dialogue revealed strong support by DoD for biodiversity conservation on military lands and affirmed that conservation of the department's exceptional natural heritage is important to the military for various reasons (Box 1.1). The report that emerged from that dialogue contained suggestions for clarifying and improving military policies and programs, and for integrating mission planning and biodiversity conservation (Keystone Center 1996). One specific recommendation was to develop a biodiversity conservation handbook that could assist installation natural resource management staff and mission leaders. In response, DoD commissioned the first edition of this guide, *Conserving Biodiversity on Military Lands: A Handbook for Natural Resource Managers* (Leslie et al. 1996). A central element of that first edition was the creation of a “model process” for putting the theory of ecosystem management into a practical framework for use at the installation level.

Box 1.1: Importance of biodiversity conservation for the military mission

The Keystone Dialogue on DoD Biodiversity Management summarized key reasons why biodiversity conservation is important for meeting the military mission (Keystone Center 1996). These include:

- Biodiversity conservation is essential in sustaining the natural landscapes required for the training and testing necessary to maintain military readiness. Managing for biodiversity can help ensure that lands and waters are maintained in a “healthy condition” and thereby facilitate greater flexibility in land use for military operations.
- Biodiversity conservation is a central component of ecosystem management, which has been embraced as the DoD’s natural resource management strategy. Given the DoD’s significant investment in conserving and protecting the environment, this strategy promises the greatest return on investment—it is simply the right thing to do and the smart way of doing business.
- Biodiversity conservation can expedite the compliance process and help avoid conflicts. Proactive management for biodiversity can provide greater certainty in mitigation for environmental impact assessment processes under the National Environmental Policy Act as well as consultation processes under the Endangered Species Act.
- U.S. citizens demand that federal land managers demonstrate responsible stewardship of public lands. The practice of biodiversity conservation fosters good will within the communities surrounding military installations, which in turn engenders public support for the military mission.
- By helping to maintain aesthetically pleasing surroundings and expanding opportunities for outdoor recreation, managing for biodiversity can improve the quality of life of our nation's military personnel and their families.

Ecosystem management

Ecosystem management continues to serve as a basis for DoD natural resource management and is central to the development and implementation of INRMPs. As described in the INRMP Implementation Manual (DoDM 4715.03), DoD Components are expected to use ecosystem management on their lands “to support present and future training and testing requirements while preserving, improving, and enhancing ecosystem integrity.” A key outcome of applying ecosystem management on military lands is “maintaining and improving the sustainability and native biodiversity of ecosystems.” To accomplish this, DoD Components are expected to conduct installation programs and activities to “identify, maintain, and restore the composition, structure, and function of natural communities that comprise ecosystems to ensure their long-term sustainability and biodiversity at landscape and other relevant ecological scales to the maximum extent that mission needs allow.” To support DoD’s implementation of ecosystem-based management, the INRMP Implementation Manual also identifies several key principles, summarized in Box 1.2.

Box 1.2: Principles for ecosystem management on DoD lands

The INRMP Implementation Manual (DoDM 4715.03) identifies several key principles for incorporating ecosystem-based management into installation natural resource management activities.

- Maintain and improve the sustainability and native biodiversity of ecosystems— Conduct programs and activities to identify, maintain, and restore the composition, structure, and function of natural communities that comprise ecosystems.
- Consider ecological units and timeframes—Consider the effects of programs and actions at spatial and temporal ecological scales that are relevant to natural processes.
- Support sustainable human activities—Consistent with mission requirements, support multiple use and sustainable development.
- Develop a vision of ecosystem health—Working with all interested parties, collaborate in developing a shared vision of what constitutes desirable future ecosystem conditions.
- Develop priorities and reconcile conflicts—Along with stakeholders, prioritize the ecosystem-based management objectives and the methods for meeting those objectives.
- Develop coordinated approaches to work toward ecosystem health—Involve the military operational community early in the planning process; develop a detailed ecosystem management implementation strategy based on the vision described above; meet regularly with regional stakeholders; incorporate

ecosystem management goals into strategic, financial, and program planning and design budgets; and prevent undesirable duplication of effort and minimize inconsistencies in programs affecting ecosystems.

- Rely on best science and data available—Ecosystem management is centered on scientific understanding of ecosystem composition, structure, and function; use established standards for the collection, taxonomy, distribution, exchange, update, and format of ecological, socioeconomic, cartographic, and managerial data.
- Use goals and objectives to monitor and evaluate outcomes—Implementation strategies should include specific and measurable objectives and criteria to evaluate activities in the ecosystem.
- Use adaptive management—Develop flexible management practices to accommodate the evolving scientific understanding of ecosystems and adjust as necessary based on, at a minimum, annual reviews.
- Implement through installation plans and programs—Work with stakeholders to identify an ecosystem's desired future conditions and incorporate implementing activities, as appropriate, in installation INRMPs, ICRMPs, and other planning and budgeting documents.

Adaptive management

Adaptive management has also become a foundational element of DoD natural resource management efforts. Adaptive management most simply means “learning by doing and adapting based on what’s learned” (Walters and Holling 1990). The essence of adaptive management is recognition of alternative hypotheses about how a system functions and may respond to management interventions, together with an assessment of these hypotheses based on monitoring and empirical data (Williams and Brown 2012). The INRMP Implementation Manual (DoDM 4715.03) calls for the use of adaptive management by installation natural resource managers, particularly within the framework of ecosystem management.

Emerging trends in DoD biodiversity conservation

As the challenges and opportunities for conserving biodiversity on military lands continue changing, DoD’s response must also evolve. Some of these challenges involve the emergence of new threats (e.g., new wildlife diseases) or intensification of existing problems (e.g., increasingly severe wildfires and drought, continued urbanization around bases). Additionally, scientific understanding of species and ecosystems continues to improve, often benefitting from advances in research methods. These include the application of environmental DNA (eDNA) sampling techniques, the increasingly broad use of low-cost drones, and the availability of miniaturized satellite tracking devices. Similarly, there has been a continuing evolution in conservation approaches and opportunities within DoD and more broadly across the land management community. Some of these trends include a continued shift toward multi-species (rather than single species) conservation planning, a heightened emphasis on sustaining or restoring key ecological processes, and an increased focus on landscape-scale conservation and habitat connectivity. The continued evolution in DoD's response to current and future biodiversity conservation challenges has also benefited from research and conservation innovations supported by several DoD environmental funding programs, including the Legacy Resource Management Program, Readiness and Environmental Protection Initiative (REPI), Strategic Research and Development Program (SERDP), and Environmental Security Technology Certification Program (ESTCP).

Since publication of the last edition of this guide in 2008 there have been several important developments in DoD's efforts to conserve biodiversity in ways that sustain the military mission. Of particular note are: 1) a major expansion in work on buffer lands and with broader landscape collaborations; 2) continued innovation in endangered species management and recovery; and 3) efforts to address the growing risks of climate change to installations and their natural resources.

Buffer lands protection

Perhaps the largest trend in DoD's conservation programs over the past two decades has been the growth in buffer land protection efforts and engagement in landscape-scale conservation collaborations. Based on the successful examples of off-installation conservation efforts—including Fort Bragg's Private Lands Initiative—DoD was provided with the authority[12] to enter into agreements with state and local governments as well as non-profit conservation organizations to promote compatible land use and protect high-value habitat around military installations (Beard et al. 2020). This authority was intended to address two key encroachment threats to installations—nearby incompatible land uses and environmental restrictions related to protection of endangered species and their habitats. The REPI initiative has been a key program for executing DoD's buffer authority. Through FY 2019, DoD has invested $962 million in this program leveraging over $853 million in non-DoD partner contributions to protect 688,258 acres of land (DoD 2020b). These partnerships share the cost of acquisition of easements or other interests in land from willing sellers to preserve compatible land uses and natural habitats near

[12] Known as "2684a authority" for the section of the U.S. Code that grants buffer authority (10 U.S. Code § 2684a).

installations and ranges that helps sustain critical, at-risk military mission capabilities. Each of the military services have programs and tools for implementing buffer land authority and applying REPI funding.[13]

REPI also supports large landscape partnerships that are intended to enhance collaborations with federal and state partners across key regions and landscapes. These include the Southeastern Regional Partnership for Planning and Sustainability (SERPPAS) and the Western Regional Partnership (WRP). DoD also participates in the Sentinel Landscapes initiative, a partnership with the Departments of Agriculture and the Interior that is designed to work with private landowners in key landscapes to advance sustainable land management practices around military installations and ranges.

Flexibility in endangered species management

Management of federally listed endangered species continues to be one of the most pressing issues for installation natural resource managers. There has been a growing effort in recent years to develop innovations in conservation approaches and regulatory mechanisms that can both increase mission flexibility as well as enhance species conservation outcomes (Li and Male 2020).

Historically, much of DoD's endangered species work has been reactive, focusing on regulatory compliance and required agency consultations. Increasingly, however, DoD is pivoting to a more proactive approach to threatened and endangered species management that takes a broader perspective on where and how to recover species and reduce mission constraints. This includes an increased emphasis on conserving populations of "at-risk" species[14] to avoid a need for their listing under the Endangered Species Act. It also includes an expanded focus on rebuilding listed species populations to achieve recovery goals (and ultimately delisting), rather than simply avoid further harm to the species. Recent successful species recovery efforts that have led to delistings include the black-capped vireo (*Vireo atricapilla*), island night lizard (*Xantusia riversiana*), and Kirtland's warbler (*Setophaga kirtlandii*).

To achieve more such species recoveries, there is a growing recognition that DoD needs to engage in partnerships and conservation actions that go well beyond installation boundaries. In addition to investing in buffer land protection (through easements or acquisitions as described above), this includes the ability to invest in off-base habitat stewardship and species management activities. For instance, as part of Eglin Air Force Base's work on the endangered reticulated flatwoods

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[13] Additional information on REPI can be found in Chapter 6.

[14] Imperiled or vulnerable species that are not currently listed under the Endangered Species Act; see page xx for a more detailed definition of "species at risk" as used by DoD.

salamander (*Ambystoma bishopi*), the base supported species management efforts taking place on adjacent state-managed land. The capacity to fund such off-installation management actions is possible due to new authorities under the Sikes Act that include the ability to provide lump sum endowments to cover the future costs of species management and improvement activities.

To promote additional regulatory flexibility in managing listed species on military lands, in 2018 DoD and the Department of the Interior established a Recovery and Sustainment Partnership (RASP) initiative. This joint effort is designed to develop collaborative conservation initiatives and innovative regulatory approaches with the potential to enhance conservation outcomes for listed and at-risk species. Central to this initiative is focusing attention on a set of priority species that offer opportunities for significant progress both in terms of species conservation and enhancing military effectiveness.

Climate adaptation and resilience

A rapidly changing climate poses a growing threat to biodiversity across the United States and around the world. Accordingly, climate adaptation is fast becoming an overarching framework for achieving biodiversity conservation and wildlife management outcomes (Stein et al. 2013, Inkley and Stein 2020). There is a growing body of evidence that the impacts of climate change on species and ecosystems are not something that may happen in the distant future, but rather already are occurring (USGCRP 2018). Climate-related threats to species and ecosystems are not only a problem from a biodiversity conservation perspective, but also have a direct impact on mission sustainability and military readiness (Stein et al. 2019). The impact of climate change on an installation’s natural resources can decrease the suitability of training and testing sites and lead to new limitations on the timing of training and other activities. Climate impacts that undermine the protective benefits that natural systems provide to installation assets can expose facilities and operational assets to significant damage. And finally, a changing climate can complicate or impede regulatory compliance, including for endangered species conservation and wetlands protection, resulting in increased operational costs or training restrictions.

Climate adaptation refers to efforts designed to prepare for, manage, and reduce the impacts and risks of a changing climate. Indeed, adaptation can best be understood as a form of iterative risk management. Based on an understanding of observed and projected climate-related changes, managers can assess climate vulnerabilities to an installation’s natural resources, along with any resulting risks to mission capabilities and assets. Appropriate strategies and actions can then be developed and implemented as a means of reducing mission risks, sustaining installation natural resources, and meeting legal obligations for environmental protection. Because climatic changes are ongoing, assessment of climate-related risks, as well as associated adaptation plans, will need to be revisited and updated on a periodic—or iterative—basis.

In 2016, DoD issued a directive on climate adaptation and resilience (DoDD 4715.21). The need to address climate change is also now incorporated into DoD's Natural Resources Conservation Program Instruction (DoDI 4715.03) as well as the INRMP Implementation Manual (DoDM 4715.03). Climate resilience has also been added as a designated purpose under the DoD's REPI buffer authority.

To assist installations in addressing the risks posed by climate change, DoD released "Climate Adaptation for DoD Natural Resource Managers" (Stein et al. 2019) together with an associated "Commander's Guide" (Stein et al. 2020). These tools are designed to help natural resource managers and mission leaders effectively incorporate climate considerations into INRMPs and other plans in order to sustain installation resources and support the military mission. The guide offers an overview of relevant climate science, summarizes major climate impacts to installations, and offers insights and resources for understanding how climatic changes may affect various installation resources and INRMP program elements. The guide lays out a structured yet flexible six-step adaptation planning process that includes an assessment of climate vulnerabilities and risks and the design of strategies and actions to reduce key risks (Box 1.3).

Box 1.3: Overview of INRMP climate adaptation planning process

This six-step adaptation planning process provides a structured yet flexible way to incorporate climate-related concerns into INRMPs as a means of sustaining military mission (from Stein et al. 2019).

Step 1. Set Context for Adaptation Planning

- Conduct program scoping
- Assemble planning team/engage stakeholders
- Compile background information

Step 2. Assess Climate Vulnerabilities and Risks

- Project future conditions
- Assess vulnerability of target natural resources
- Assess resulting impacts and risks to military mission

Step 3. Evaluate Implications for INRMP Goals and Objectives

- Evaluate continued achievability of existing goals
- Update climate-compromised goals and objectives

Step 4. Develop Strategies and Actions to Reduce Climate Risks

- Identify potential adaptation strategies and actions
- Evaluate the effectiveness/feasibility of possible strategies
- Select priority risk reduction measures

Step 5. Implement Adaptation Actions and Projects

- Identify project requirements and dependencies
- Incorporate actions/projects into INRMP implementation table

Step 6. Monitor and Adjust Adaptation Actions

- Define expected results of adaptation strategies
- Monitor project effectiveness and ecological responses
- Adjust actions and plans as needed

Building capacity for managing biodiversity

The Sikes Act requires that a sufficient number of professionally trained natural resource management personnel are available to carry out DoD's responsibilities under the Act, including the preparation and implementation of INRMPs. Fortunately, there has been considerable and continuing progress in developing a cadre of trained military natural resource professionals, along with guidance and tools to assist them in their work. Some of the notable efforts that are helping to build professional capacity to conserve biodiversity on DoD lands include the following:

DoD Natural Resources Program (https://www.denix.osd.mil/nr/), housed within the Office of the Secretary of Defense (OSD), provides policy and guidance, management and oversight, and tools and resources to the military services so that each DoD Component can implement their natural resource programs in compliance with federal laws and executive orders. The program offers training and tools on topics such as implementation of the Sikes Act and Endangered Species Act, and coordination with State Wildlife Action Plans, as well as regional threatened, endangered, and at-risk species workshops. This program also administers the Legacy Resource Management Program, which funds high priority national and regional natural and cultural resources projects that support military readiness and enhance DoD conservation objectives. Natural Resources Program priorities include preventing new endangered species listings, facilitating species de-listings, and encouraging off-base conservation to enhance on-base mission flexibility.

Cooperative Ecosystem Studies Units (CESU) (http://www.cesu.psu.edu/), administered by the National Park Service, provide DoD entities a mechanism by which they can partner with universities, non-profits, state resources agencies, or other federal agencies to help meet their natural resource research and management needs. The purpose of the CESU network is to provide research, technical assistance, and training to the federal land management, environmental and research agencies and their partners. DoD became a CESU federal agency partner in 2000 and is a member of all 17 regions in the CESU national network.

National Military Fish and Wildlife Association (NMFWA) (https://www.nmfwa.org/) serves as the primary professional society for many DoD natural resource managers and holds an annual training workshop in conjunction with the North American Wildlife Conference. NMFWA has a variety of formal work groups, ranging from climate change and wildland fire to recreation and law enforcement, that allow DoD resource managers to communicate, network with, and learn from peers working on similar issues.

DoD Partners in Flight (DoD PIF) and DoD Partners in Amphibian and Reptile Conservation (DoD PARC). Two cooperative networks are in operation that focus on particular organisms—birds and herpetofauna—on military lands. DoD PIF (https://www.denix.osd.mil/dodpif/index.html) was established in 1991 and helps support DoD natural resource managers to improve monitoring and inventory, research and management, and education programs that involve birds and their habitats. DoD PARC (https://www.denix.osd.mil/dodparc/) was launched in 2009 and provides a framework for managers to effectively manage amphibians and reptiles on DoD lands by focusing on habitat and species management, inventory, research, and monitoring, and education, outreach, and training.

Maintaining readiness, sustaining biodiversity

The primary mission of the DoD is to provide the military forces needed to deter war and ensure our nation’s security. To that end, military lands are important national assets for training military forces and testing and deploying new weapon systems. Training provides troops with the combat skills they require to be successful and to ensure their safety, and realistic training increases their success and survivability in combat. Similarly, realistic testing enhances the reliability and effectiveness of weapons systems to be used in combat. Realistic training and testing require the availability of natural environments that reflect the conditions under which troops may expect to face combat operations. As a result, maintaining healthy and functioning ecosystems on the nation’s military lands is not a luxury, but rather an essential component of maintaining military readiness.

Biodiversity is the overarching concept used to refer to the variety of species and ecosystems that make up the natural world, and maintenance of realistic training conditions depends on conservation of these biological and ecological resources. Many defense installations are found in some of the nation’s most biologically rich regions, and accordingly, military lands harbor a particularly diverse array of wildlife, including a significant number of the nation’s federally listed endangered species. As a result, the DoD’s land management responsibilities include stewardship for hundreds of our nation’s rarest species and most characteristic habitats. And while these stewardship obligations can create conflicts with operational needs, a growing body of experience—such as the successful conservation of red-cockaded woodpeckers at Fort Bragg—indicates that when these issues are approached creatively and with a solution-oriented spirit, biodiversity conservation and maintaining military readiness can go hand-in-hand.

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2. Understanding Biodiversity Conservation

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> "The last word in ignorance is the man who says of an animal or plant: 'what good is it?'. If the land mechanism as a whole is good then every part is good whether we understand it or not. If the biota in the course of eons has built something we like but do not understand then who but a fool would discard seemingly useless parts. To keep every cog and wheel is the first precaution of intelligent tinkering."
>
> — Aldo Leopold, Round River

Introduction: Components of biodiversity of concern

For anyone tasked with the conservation of biodiversity, the idea of planning to preserve the "totality of genes, species, and ecosystems of a region" is daunting. Attempting to implement the conservation of biodiversity, as defined, is an overwhelming challenge. It is far too easy to become stuck in the weeds of the details and to try to manage everything individually. A land manager will justifiably ask, "How can I hope to manage for all species on my installation? How in the world do I manage for landscape function? Where do I start?"

This chapter introduces the science of biodiversity conservation and discusses many issues central to biodiversity conservation in the context of military lands.

While it is important to keep all biological levels of organization in mind, one does not need to plan, or manage, for each. Planning for conservation action leans most heavily on what is commonly called the coarse filter/fine filter approach (Noss 1987). The coarse filter approach focuses on ecological systems–ecosystem management—whereas the fine filter approach emphasizes individual species management. Successful biodiversity management relies on both. In brief, the reasoning supporting this paired approach is that most common species are "captured" by the coarse filter because of their association common ecosystem types and the processes that support them. Those species that are not sufficiently captured in the coarse filter (e.g., rare, habitat specialists, and wide ranging or migratory) need then be caught by the fine filter (Groves 2003).

While most resource managers, and many non-biologists, have an intrinsic understanding of these levels of biological organization, it is always a good idea to review these terms and concepts as their precise meanings are often different from an often-idiosyncratic understanding.

Populations

A population is typically defined as a group of interbreeding individuals of the same species living within a defined area. The key to this definition is that individuals within a population must, at the very least, have the potential to interbreed. Thus, dispersal potential can drive the size of a population. Many wide-ranging species, for example migratory birds, have huge populations that can span thousands of square kilometers. More stationary species, for example, bog lemmings, will have more restricted population sizes where the entire population exists within a small peat bog.

Meta-populations, natural and derived

Between these two extremes, most species exist as constellations of sub-populations where most individuals interact within their small group, with the rare individual dispersing over greater distances. These species are structured as a meta-population, or a population of sub-populations. These sub-populations are distributed across a landscape (or a military installation) as many “occurrences.” Each occurrence has a low probability of persisting over the long term, in isolation from other occurrences. Most sub-populations are simply too small to be resilient to environmental variation, or demographic or genetic bottlenecks. Neighboring occurrences are constantly providing, at some low but critical rate, “new blood” into a given sub-population. These neighboring occurrences also provide sets of “founder” genes that will re-colonize a vacant area.

Meta-populations can be envisioned, then, as a galaxy where each “star” is a sub-population. These “stars” are winking off and on as sub-populations disappear, and then reappear as the vacant areas are re-colonized. The space between these stars—the voids—is not suitable habitat for these creatures, and so is simply not available for colonization by this species.

Sources and sinks and their importance

Upon reflection, it becomes obvious that all sub-populations are not the same. Some occur on tiny patches of acceptable habitat, and never grow to more than a small number of individuals. These, of course, never really escape the consequences of being in a “population bottleneck,” and many have a low probability of persisting in isolation. Others occur on large areas of acceptable habitat and, thus, tend to exist as large healthy populations. These have greater demographic and genetic resilience, and hence a greater probability of persistence. Simply because of their large size, these populations tend to be the source of most of the dispersers that colonize vacant patches and reinvigorate the small sub-populations both by their numbers and by their genetic diversity. These are thought of as “source” sub-populations, whereas the smaller occurrences which tend to absorb migrants, but do not provide dispersers, are considered “sinks.”

The generalization that small populations tend to be sinks, and large populations sources, is, like all generalizations, only true to a point. The key, which is often difficult to measure, is whether the population produces significant numbers emigrants or not. Source populations do, sinks do not. In general, “sink” sub-populations will not persist without continual immigration from “sources.” Thus, the destruction of a single “source” sub-population can result in the extirpation of many surrounding “sinks” even if they are not directly impacted.

The Sikes Act requires military installations to prevent the loss of threatened, endangered, and listed species found within their boundaries. Understanding the ecology of those species, and how their populations and sub-populations are distributed, is key to meeting this requirement. Conserving a wide-ranging species like the bald eagle might be accomplished simply by protecting a limited number of nesting sites—as only a small piece of a much larger population exists on site. The Karner Blue butterfly, in contrast, exists as a meta-population where sub-populations exist in ephemeral patches of host plants. Conserving this species requires an understanding of the disturbance dynamics creating these patches of host plants, and the dispersal capabilities of the butterfly, so as to manage the entire meta-population and not just a few occurrences, each with a low probability of persistence in isolation. Understanding and managing a meta-population often requires looking beyond an installation’s borders to sub-populations on neighboring lands.

Communities and ecosystems

How are communities and ecosystems different than “habitat”? Managing for a species invariably means managing its habitat. Habitat (which is derived from the Latin for "it inhabits") is the place where a particular species lives and grows. It is essentially the environment—at least the physical environment—that surrounds (influences and is utilized by) the species population. The term was originally defined as the physical conditions that surround a species population, or an assemblage of species (Clements and Shelford, 1939). Wildlife managers, in particular, tend to focus on habitat management–identifying and manipulating those environmental factors limiting a targeted population’s size (Leopold 1933, Yoakum and Dasmann. 1971). Scientists often expand the concept of habitat to include an assemblage of many species, living together in the same place. Thus, for example, wildlife managers often work to improve shorebird habitat. The U.S. Fish and Wildlife Service (FWS) has spent many millions of dollars managing for breeding habitat for migratory waterfowl in the prairie pothole region of North America. Ecologists regard the habitat shared by many species to be a biotope—a place where a community of species lives.

The concept of habitat is not synonymous with that of the natural community or ecosystem. A natural community is the assemblage of plants and animals sharing the same biotope and interacting with each other. When one speaks of a natural community, the focus is on the species and their interactions. The biotope, then, is the biophysical stage on which these species and their interactions occur. Communities typically reoccur across a landscape as they track habitat conditions. As such, communities do not occur at a single, specific spatial scale. Vegetation communities are often perceived as the classic community, but one can also describe the smaller community existing within a fallen log, or ephemeral community within a vernal pool.

An ecosystem, then, can be thought of as the whole picture; the combination of a natural community and its habitat (or biotope). As such, an ecosystem can extend far beyond even a large military installation. But ecosystems are more than just a community in its habitat. The concept of the ecosystem includes dynamic ecological processes (see below) and the recognition that species composition (i.e., the community) will change over time as well as over space. Every species within a community responds to the environment differently from the others. Similarly, each species interacts with different suites of other species. As conditions change, as they certainly do within military installations as in other environmental settings, some species become more abundant, while others become rarer.

Natural disturbances, ranging in size from gaps called by fallen trees to massive wildfires, all affect species abundance and distribution differently (Picket and White 1986). Thus, ecosystems are neither static nor homogeneous. Rather, they are composed of “patches” of various sizes and ages, and the relative abundance and distribution of these patches is crucial to maintain the full suite of biodiversity within an area. Maintaining ecological processes, such as fires, floods, and periodic disease epidemics, is the keystone of successful ecosystem conservation. Indeed, the core of the ecosystem-based management approach is the understanding that the persistence of all biodiversity within an area is contingent on the persistence of this crazy-quilt pattern of disturbed and recovering patches. Management, then, needs to focus on the dynamic processes creating this pattern and not on maintaining a static structure and condition. Military activities can mimic some natural disturbances, and thus can often be integrated into a biodiversity management plan.

Natural landscapes

From a biological perspective, a military installation is not an island, existing in isolation. It lives within a larger landscape comprising both natural and anthropogenic systems. A natural landscape can be thought of as the spatial scale at which ecosystems reoccur (Forman 1995). Meta-populations often function at this scale, with sub-populations occurring in ecosystem patches scattered throughout the landscape. Many wide-ranging species are very sensitive to the landscape pattern.

These species often use, and require, two or more ecosystems for survival. These ecosystems may often not be congruent, and the species must travel through the landscape. Smaller installations may encompass only a small portion of the landscape mosaic and, as a result, critical habitats and ecosystems may only occur off-site. In these circumstances, it is very important to look beyond the installation's boundaries.

Alternatively, a large military installation can often be fruitfully managed as a landscape unto itself—or sometimes as a microcosm of a much larger landscape. Natural buffer zones, impact areas, training areas, and other developed lands together join to form a landscape mosaic. There is great opportunity to build upon this existing mosaic, creating missing patches or systems, and enhancing others to affect significant conservation results.

It is at this scale that concerns about variety, variability, multiple biological levels, and sustaining processes come to the fore.

Regardless of size, the encroachment on an installation's boundaries presents challenges to achieving both the military and the biodiversity conservation missions. The conversion of lands within the installation's natural landscape has consequences to the biodiversity on-site by fragmenting and isolating subpopulations of key species and changing the patch structure driving important natural communities out of their natural range of variation (NRV). Encroachment also increases the likelihood of unnatural disturbance, changes the disturbance regimes important to ecosystem function, and can be a source of invasive species.

Ecoregions

Many organizations, including all federal land management agencies use ecoregions as a foundation for planning. These regions are large areas that have characteristic, and often geographically distinct species, communities, and landscapes. The Nature Conservancy, the Environmental Protection Agency (EPA), and the Bureau of Land Management (BLM) have completed Ecoregional Assessments that identify and map the distribution of all ecological communities within the regions and the provide information on the integrity of these communities. These assessments also provide information on the rare, threatened, and imperiled species with the areas of study.

Placing a military installation within its ecoregion can provide important information as to the relative importance of the installation's biodiversity from a regional, national, and global perspective.

Ecological processes

In most human-dominated landscapes, including most military installations, native ecosystems have been fragmented and now occur as islands in seas of intensively impacted and managed lands. As mentioned above, this fragmentation harms species populations by restricting the movement of those pioneering individuals necessary to found new sub-populations and reinvigorate population sinks. Similarly, fragmentation changes how natural disturbance plays out on the landscape. Fires, for example, may be prevented from running across the landscape by the cutting of firebreaks. Thus, vegetation patches may persist for greater periods of time between fires, resulting in greater fuel accumulation, and subsequently more severe fires when they do occur.

The intensity and impact of any ecosystem process varies over time. Species and ecosystems respond to, and are organized around, these natural ranges of variation within these ecological processes. Thus, fires returning every five years will result in a very different community than when they return every hundred years. This is exemplified by both the longleaf pine forests of the southeast and ponderosa pine forests of the Rocky Mountain west. While there was, of course, variation in the frequency of naturally-ignited fires, typically any given patch would burn every ten years or so. This resulted in open forests, with relatively few large trees in a matrix of grasses and forbs. Both long-leaf and ponderosa pines have thick, fire-resistant bark and so the adult trees are not damaged by low-intensity ground fires. Active fire suppression over the past several decades has decreased the fire frequency and allowed other, less fire tolerant, species to get toeholds. Now, when fires do occur, the fire climbs into the canopy and the results are conflagrations that consume everything rather than the historically less intense ground fires that did not impact the trees.

Ecological processes that are impacted by military land uses include:

- fire, both in terms of frequency, seasonality, and intensity
- flooding, including frequency, duration, sediment movement
- disturbance of turf by rodents and large mammals in prairie systems
- sheet flow, and other water movement patterns in desert systems

Active ecosystem management by humans can mimic historic ecological processes and their effects; conservation managers can achieve both their conservation goals and meet the needs of the military. However, management with an eye toward variation is more challenging than managing for consistency. A large forest ecosystem will be very different if every management unit is burned on a 10-year cycle than if units were burned randomly on a 5- to 30-year pattern. The former is easier to plan and to implement, as managers can anticipate needs many years in advance. The latter is more complex structurally, and hence, harbors greater biological diversity.

Ecological integrity

The coarse filter/fine filter approach centrally recognizes the need to conserve biological diversity in part by conserving the natural disturbance regimes that contribute to the diversity of any given landscape. However, ecosystems everywhere today face disturbances of both unusual patterns and types as a result of climate change, the introduction of chemical pollutants and non-native species, among others. Consequently, management plans must also address the need to conserve both the “resistance” and “resilience” in ecosystems. Resistance refers to the capacity of ecosystems to tolerate disturbances without exhibiting significant change in structure and composition. Resilience, in turn, refers to the ability of a system to recover from disturbance, if the disturbance exceeds the capacity of the system to resist changing at all (Holling 1973, De Leo, G. A., and S. Levin. 1997, Lindenmayer, D. and others, 2008).

The central tenet of an ecological integrity assessment is that ecosystems with greater ecological integrity, as defined here, will be more resistant and resilient to the effects of changing patterns and types of disturbance (Parrish, Braun et al. 2003).

The concept of ecological integrity, associated measurement and monitoring approaches, and other closely related topics are addressed in more detail in Chapter 8.

Geographic and ecological scale

As planners focus on a specific conservation question to address in the INRMP, one of their first decisions is to determine the appropriate spatial scale for analysis. In order to create successful long-term strategies for protection or management, explicit consideration of biological and ecological patterns at different scales is important. Species differ in their size, mobility, physiology, and life history, and each responds to the same physical setting in different ways and at different scales (Addicott et al. 1987; Kotliar and Wiens 1990). Thus, the planning scale appropriate for one species is rarely fully appropriate for others.

Different species, communities, and ecological processes occur over different quantifiable spatial and temporal ranges, and as a result, each can be observed over a set of characteristic scales. Additionally, ecosystem threats, and effective methods and actions for alleviating them, also have characteristic scales at which they can and must be observed. Natural systems can experience threats to their continued function at many different geographic scales. Although specific threats to individual species or small groups of species often can be recognized, ranking the many biodiversity elements or ecosystem threats to determine priorities for conservation is a challenging, but necessary task.

Central to the ideals of conservation planning is that a method based explicitly in theories of conservation biology (e.g., redundancy, resilience, complementarity) that results in actions being taken to preserve biodiversity has a better chance of long-term success and is less biased than a purely ad hoc or reactionary approach (Margules and Pressey 2000, Groves 2003). However, the complex nature of ecosystems and their component biodiversity and integrative function (see O'Neill et al. 1986) makes conservation planning, at best, difficult. To simplify the problem such that it becomes manageable requires selecting a scale of analysis appropriate to the questions being asked and the mechanisms available for implementation.

The obvious patterns of scale perceived by the conservation planner rarely coincide with the spatial structure and configuration that drive the behavioral and ecosystem processes that are the subject of conservation efforts. For example, Poiani et al. (2000) proposed four spatial scale-levels to guide conservation planning efforts: regional (millions of hectares), coarse (tens of thousands to millions of hectares), intermediate (hundreds to tens of thousands of hectares), and local (hectares to thousands of hectares) (Figure 2.1).

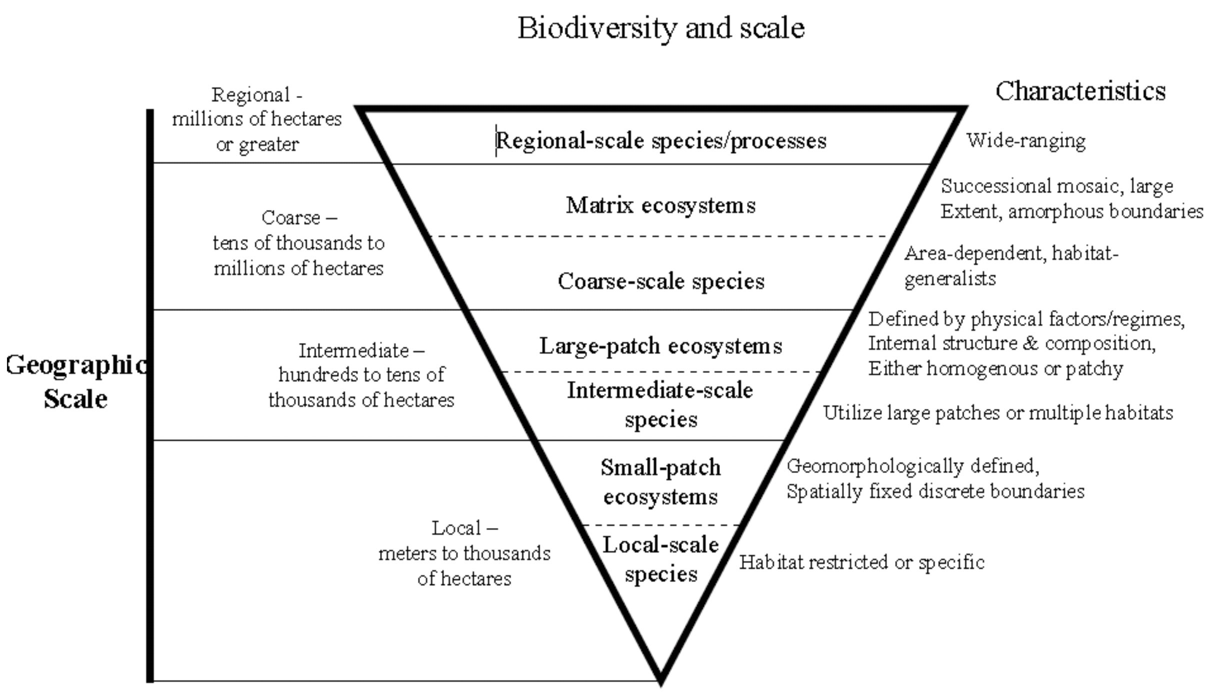

Figure 2.1. Biodiversity and scale interactions as envisioned by Poiani et al. (2000) produce four logical divisions for the purposes of conservation planning.

Sanderson et al. (2002) suggested that “landscape species,” by merit of their extensive use of a landscape, capture the needs of many other species, and that planning for persistence of these would benefit conservation of many other species as well. Such planning frameworks, however, focus largely on the spatial extent of use, while ignoring the grain and pattern within a planning area. Andelman et al. (2000) reported that such “umbrella” species provide for the conservation needs of other species no better than do randomly selected species. This is a manifestation of the problematic issues of spatial scale.

Ideally, planning should be framed at a variety of scales. Using a hierarchical (nested) framework of scales not only ensures that a wide range of conservation targets and threats can be addressed, but also helps translate conservation priorities between scales, thereby providing larger-scale context to specific actions, while at the same time showing how fine-scale actions (e.g., actions on an installation) can contribute to coarse-scale (e.g., landscape or regional) conservation priorities. The conservation planner may be able to address only one question at one scale within the hierarchy at any one time, but must remain cognizant of its relationship to planning at other scales.

The choice of scale for a conservation plan is necessarily limited by the available data. The scale at which data are collected determines not only the detail at which features on the ground can be represented, but also the number of features that can be resolved. Both factors affect the inferences that can be drawn from spatial data (see discussion below). In most cases, the base data will consist of landcover and infrastructure, along with topographical data (elevation, slope, aspect). Which data sets are used will, in turn, depend upon the target of interest and the scale at which it responds to the environment (e.g., how species perceive their habitat).

Both natural and human-caused processes have characteristic frequencies and magnitudes that result in landscape patterns detectable only at certain scales. In this light, grain refers to the smallest elements upon which a process depends, and extent refers to the coarsest set of patterns a process produces (Addicott et al. 1987; Kotlair and Wiens 1990). For example, timber harvest typically has as its finest unit a forest stand which would define the grain of timber harvest, and the extent would be defined by the total area of harvestable forest land. Thus, from an ecological or management perspective, scale is tied directly to a specific process and is not an inherent property of a system (Wiens and Milne 1989). In other words, there is no one “ecological scale,” even for a single species, and a significant challenge in conservation planning is defining the right scales for assessing the effects of specific actions and ecological processes.

Why scale is important to conservation planning

In the context of conservation planning, scale has important implications that relate to:

- selecting processes, targets, and threats for consideration;

- the relationships between targets, their key attributes (Parrish et al. 2003), and processes or threats; and
- the kinds of data used and the applicability of planning results.

The first reason scale is important to conservation planning is that effects of natural and human-caused processes and events can only be observed or measured across specific scale ranges. Populations and distributions of conservation targets are not fixed in space and time but vary in response to natural and human-caused processes and events (Figure 2.2). In one sense, species distribution is a response variable dependent upon habitat covariates such as vegetation type, elevation, etc., which, in turn, are determined by underlying physical and biotic processes.

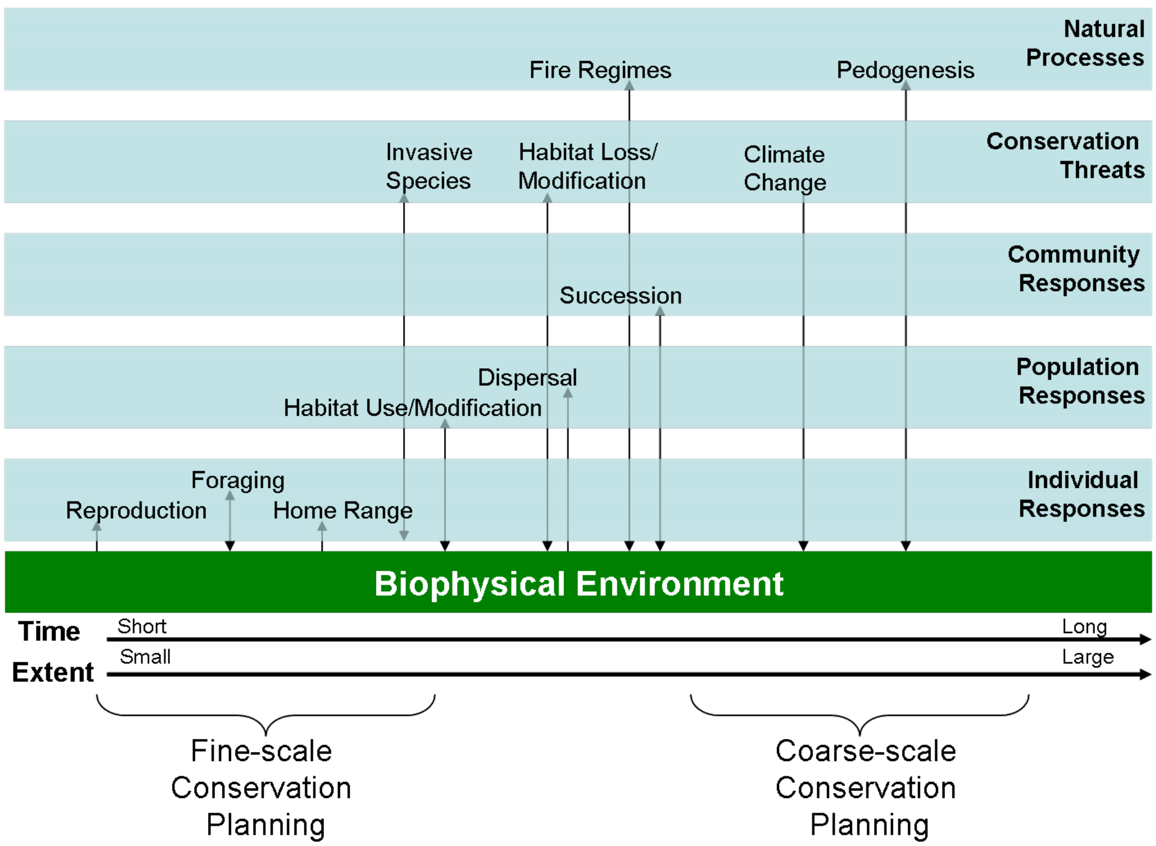

Figure 2.2. Biological, management, and biophysical process over spatial and temporal scales. Processes at finer scales are constrained by those operating at longer or larger scales. Thus, conservation planning at fine scales must take these constraints into consideration.

Successful conservation planning starts with knowing what processes are significant to the persistence of a conservation target, both those that benefit it and those that threaten it (Parrish et al., 2003). Hence, the processes relevant to a conservation target will help determine the scales at which conservation planning should take place.

A second reason scale is important to conservation planning is that a species' associations with its environment can appear different when observed at different scales. Consider the association between sage grouse (*Centrocercus urophasianus*) and agriculture at three different scales. Historically, sage grouse were found in sagebrush habitats across much of the western United States. The loss of sagebrush habitat to agricultural development is one contributor to their widespread decline across their range. So, at a range-wide scale, sage grouse are negatively associated with agriculture. However, sage grouse do use agricultural lands, because they are a rich source of the insects hens need for rearing their chicks. At an intermediate scale that encompasses multiple populations (e.g., the extent of one or several counties), good sage grouse habitat is considered to have a mix of high-quality sagebrush habitat and agricultural fields (Schroeder et al. 1999). So, at this scale, sage grouse are positively associated with agricultural lands. Agricultural lands, though, do not provide important resources like cover, nesting habitat, or lekking areas that are important aspects of the sage grouse life cycle, and lack of these exposes sage grouse to increased risk of predation or disturbance. At the scale of an individual population, high quality sagebrush habitat is the essential, and often limiting factor to sustaining sage grouse populations in the face of agricultural encroachment. Thus, at the finest scales, sage grouse are again negatively associated with agricultural lands. In a hierarchy of conservation plans, agriculture can be treated as a component of habitat or a threat, depending upon the scale of analysis.

A third reason scale is important to conservation planning is that the synthesis of different data layers into an analysis scale produces an output that is specific to that scale. This means the results of a particular conservation plan cannot be scaled down, because data have been lost in aggregating to the analysis scale, and results cannot be predictably scaled up. When results from these models are downscaled to a scale of concern, such as 10-km grain, their accuracy is limited to that of the original projection. Ideally, the choice of an analysis scale for conservation planning would be the result of consideration of the scales relevant to the conservation targets. In practice, however, this is often not done. Analysis scales are selected arbitrarily or by convenience, leading to planning results that may not be applicable to the scales at which actions will be taken.

These issues are addressed in greater depth in Chapter 8.

Sound science in conservation planning

Regardless of the approach selected, all successful INRMPs share several key elements:

There are clearly stated, mutually supportive conservation/management goals that drive the development of the plan. The goals communicate a compelling vision for the conservation and management of the planning area, park or landscape or resource.

There are clear statements of desired conditions generated from goals and include a description, metrics and measures of the resource. The desired conditions then drive the development of measurable program or project objectives. These objectives should translate the intention of the goals into measurable outcomes. The desired conditions, therefore, define what constitutes success. The objectives define what constitutes progress.

Both goals and statements of desired conditions call for strategies that can be implemented within a reasonable period of time and within a reasonable budget. Effective goals and desired conditions are sufficiently clear that they can guide decisions about priorities, sequencing, and required investments in the actions needed to achieve progress and ultimate success.

The plan explicitly identifies conservation strategies and objectives tied to each goal. Typical strategies are developed to abate the impacts of human activities or human-caused changes on the landscape, or restoration or rehabilitation of areas incapable of natural recovery. Some strategies also identify actions to prevent threats to the focal conservation resources manifesting themselves.

Each objective has a related monitoring assessment. Well-written objectives point to measurable parameters and outcomes that can be used to monitor progress and document success. The monitoring assessment is set into place at the same time conservation actions are initiated.

The most useful plans explicitly address the challenges of implementing conservation strategies at the appropriate scale. Too often, plans identify conservation strategies with no consideration of the potential, or cost, of implementation. For example, while mechanical thinning of forests can be used to manage fuel loads, implementation of this practice across several hundred thousand acres would likely involve insurmountable obstacles of cost and practicality. Successful conservation plans recognize such challenges and propose activities that can be reasonably implemented.

Plans are treated as living documents from the onset and are consistently modified and updated. Such plans explicitly document all challenges encountered by the planning team including: (1) gaps in the knowledge of the team, (2) assumptions that were made during the planning process including assumptions about the biology or ecology of the focal ecological resources and (3) assumptions about biodiversity which is thought to be captured, using these surrogate focal ecological resources.

Living plans also identify additional information needs that could help improve the plan, change the priorities, or impact the conservation strategies.

Conservation in practice

> "The cowman, who cleans his range of wolves, does not realize that he is taking over the wolf's job of trimming the herd to fit the range. He has not learned to think like a mountain. Hence, we have dustbowls, and rivers washing the future into the sea."
>
> — Aldo Leopold, A Sand County Almanac

Learning to think like a mountain: Tools for conservation practitioners

Biodiversity conservation on military lands does not equate with outright preservation or the exclusion of military uses. Creatively using an ecosystem management approach and working with the military community, have produced impressive results at many installations, several of which are chronicled in this manual. One key component is to use an adaptive approach to conservation planning and implementation.

Definitions of adaptive management vary by context, but the commonalities include the appreciation that "ecosystems are not more complex than we think, but more complex than we can think" (Egler 1977). Despite this uncertainty, success is possible with thoughtful planning.

The basic premises of adaptive management are:

- We don't know enough to predict all outcomes. Changing management, and changing military activities, will undoubtedly result in unanticipated results, as will purely natural, but unpredictable, events. A key is to learn from those events, capture the learning from that experience, and build it into our understanding of the systems.
- Everything is an experiment; every project provides an opportunity to learn and improve. This doesn't mean that every activity needs to be designed as a rigorous scientific experiment. Rather, we must enter every process with our eyes open, asking two questions up front: "If this doesn't work out as I expect, what do I want to know in order to do it better next time?" And, "If this does work out, what can I learn from this place that will allow me to carry that success to other situations?"
- There is no simple protocol for implementing adaptive management. However, there are some keystones to successful adaptive management, all related to documenting the ecological and management processes, the

shared understanding of the system(s), and explicitly stating the assumptions and uncertainties before undertaking actions.

- Providing "just so" stories about why a project didn't succeed after the fact is not adaptive. Nor does it facilitate learning. The military has embedded After Action Reviews (AARs) into most of its work to overcome this. These reviews focus on four key questions: What were our intended results? What were our actual results? What caused our results? And what will we sustain or improve? Anticipating asking these questions after every management action can make management planning adaptive. Of course, this requires management teams to agree on, and explicitly state, their intended results a priori. And, taking the time to measure their actual results in a meaningful manner.

The conservation community has collaboratively developed standards and tools for designing, managing, monitoring and learning from conservation projects. This work has been codified in the Conservation Standards developed by the Conservation Measures Partnership https://conservationstandards.org/. This partnership has created a software package Miradi that helps guide planners through the process of creating an adaptive management plan. The software is available at https://miradi.org/. While it is not possible to directly translate Miradi's products into an INRMP, integrating the thought process inherent in the software can help a team create an adaptive INRMP.

Planning for biodiversity conservation

When the job is managing for a single threatened or endangered species, the focus of planning is clear: Maintain the current population(s) or the meta-population by managing habitat condition and maintaining connectivity among subpopulations. Similarly, conserving a wetland community is straightforward: Maintain the current condition, prevent encroachment and limit sediment and pollutants from entering the system. However, when one is given the task of conserving the biodiversity on an installation, the challenges mount up fast. Experience has shown managers the importance of identifying a limited number of conservation targets on which to focus planning and management efforts; you cannot plan for everything in isolation. The key is to identify and focus management on a limited number of conservation targets. These targets should capture the ecological diversity of the installation, and the variability of seral states inherent in each system.

Biodiversity conservation targets are a limited number of species, natural communities, or entire ecological systems that natural resource managers select to represent the biodiversity of a conservation landscape or protected area, and that therefore serve as the foci of conservation investment and measures of conservation effectiveness. Thus, conservation targets are simply those ecosystems, communities, or species upon which to focus planning and management efforts.

Because only a handful of targets are used to plan for biodiversity conservation, selecting the appropriate suite of targets is crucial to successful conservation planning and adaptive management. The reasoning behind such use of limited elements of focal biodiversity is richly addressed in the literature (see for example Noss and Cooperrider 1994, Christensen et al. 1996, Schwartz 1999, Poiani et al. 2000, Carignan and Villard 2002, Sanderson et al. 2002).

Thus, structured planning requires a winnowing of a relatively few key components —a.k.a. conservation targets—from the universe of possible options within the installation. The integrity, or viability, of each of these targets is defined by identifying those attributes that contribute to the target's persistence. Thus, a team that is planning for conservation at an installation could follow the following sequence to identify its targets for planning:

- Examine coarse and fine filter conservation elements and their nesting relationships.
- Aggregate the coarse filter targets, as appropriate vis-à-vis land management. For example, pocket wetlands (small constructed systems, usually designed to aid in stormwater control) may be most effectively managed as part of the larger upland matrix.
- Determine those species that are not captured and assess whether they require special attention, including wide-ranging species.
- Finalize the list of targets to be the minimum sufficient set to capture all required species, and important systems.
- Assess current integrity for each target, and if possible, how that integrity may have been changing over time.
- Based on the assessments, explicitly state the goals, management actions and desired outcomes for each of these conservation targets.

This last step can often lead to gridlock because it either feels overwhelming, or results in resource management plans that are so detailed and constrained that they can never be implemented. Managers from many agencies, and from many countries, have been experimenting with creating ways to make it more rigorous and less of an art. The successful adaptive manager can call on several tools to assist in his or her job. Three of these are the conceptual ecological models, ecological integrity assessment, and effective targeted monitoring, all three of which are described in more detail in Chapter 8.

Assessing threats to biodiversity

Measurement of threat status has gained increasing attention among practitioners and students of conservation (e.g., Salafsky and Margoluis 1999, Hockings et al.

2001, Margoluis and Salafsky 2001, Ervin 2002). Clearly, without reduction in the threats to biodiversity, those species and ecosystems that are the focus of conservation efforts will rapidly degrade and disappear. Yet, regardless of its importance, measuring threat status is insufficient on its own, for several reasons. Most significantly, a focus on threat status alone must assume that there is a clear, often linear, relationship between a threat and the ecological integrity of biodiversity. This runs counter to recent evidence of the non-linear dynamics of ecosystems and threshold effects (e.g., Scheffer et al. 2001). Secondly, a singular focus on threats can lead to a “zero-tolerance” approach to threat activities in human influenced landscapes. Under most circumstances, this is unrealistic. Thus, it is preferable to link threats assessment to ecological integrity or population viability assessments.

Here, a threat is defined as something negatively impacting a key ecological attribute. Conservation and management actions work to abate these impacts. Thus, there is a direct (and, it is hoped, clearly understood) linkage between the actions of the managers working on threats and the benefits to the ecological integrity and viability of targets of biodiversity. Again, this is addressed in greater depth in Chapter 8.

Regional conservation planning

Every military installation is only one piece of a much larger ecological matrix, or landscape. Often it is impossible to achieve the installation’s conservation mission without fostering a conservation ethic on surrounding lands. External encroachment, for example, not only impacts military activities within the installation’s boundary, but it will dramatically impact biodiversity within those bounds as well. As surrounding lands are fragmented, for example, biodiversity within the installation becomes simultaneously more isolated and more susceptible to random events. Where, at one time, a sub-population could be re-colonized or reinvigorated by migrants from surrounding populations, as those surrounding populations become extirpated, the targets on the installation are ever more likely to be lost. Similarly, patterns of disturbance often extend beyond military boundaries. As an installation becomes isolated, the managers must begin managing their land as a microcosm of the larger landscape.

It is often very useful to take even a larger perspective of the distribution of those conservation targets on an installation. Ecoregions are large areas that have been defined based on environmental variables known to influence patterns of biodiversity. Therefore, they provide an appropriate foundation for large-scale conservation planning. While even the largest installation is dwarfed by the scale of an ecoregion (tens of thousands of hectares versus millions of hectares), it is always valuable to understand how the conservation targets found within an installation are distributed across the continent. Understanding this spatial diversity can provide very useful insights into the natural variation potentially found, or managed for, on the installation. NatureServe, in collaboration with The Nature Conservancy and others, published Ecoregional Assessments for all ecoregions in North America in the early 2000s. These can be accessed at: http://www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Pages/EastData.aspx

Over the past several years the Bureau of Land Management has updated these assessments for all ecoregions having lands under BLM management. These Rapid Ecoregional Assessments are available at https://landscape.blm.gov/geoportal/catalog/REAs/REAs.page. Referring to these assessments can be extremely helpful in putting an installation's biodiversity conservation priorities in perspective.

Monitoring biodiversity

What is monitoring? The Latin root of the word monitoring means "to warn," and an essential purpose of monitoring is to raise a warning flag that the current course of action is not working. Monitoring is a powerful tool for identifying problems in the early stages, before they become dramatically obvious or critical. If identified early, problems can be addressed while cost-effective solutions are still available. For example, an invasive species that threatens a rare plant population on an installation is much easier to control at the initial stages of invasion, compared to eradicating it once it is well established. Monitoring is also critical for measuring management success. Good monitoring can demonstrate that the current management approach is working and provide evidence supporting the continuation of current management.

For monitoring to function as a warning system or a measure of success, one must understand what monitoring is and the close relationship between monitoring and adaptive management. In this handbook, monitoring is defined as the collection and analysis of repeated observations, or measurements, to evaluate changes in condition and progress toward meeting a management objective.

Monitoring is the glue that binds the adaptive management cycle. It provides information to assess success and guide future actions. To be successful, any monitoring project must reflect two key tenets. The first is that monitoring is driven by objectives. What is measured, how well it is measured, and how often it is measured are design features defined by how an objective is articulated. The objective describes the desired condition. Management is designed to meet the objective. Monitoring is designed to determine if the objective is met. Objectives form the foundation of the entire monitoring project.

The second tenet is that monitoring is only initiated if opportunities for management change exist. If no alternative management options are available, measuring a trend is futile. What can you do if a population is declining other than document its demise? Because monitoring resources are limited, they should be directed toward management actions for which management solutions are available.

When does monitoring succeed? Unfortunately, most monitoring projects are seemingly initiated in a vacuum, and thus are destined to fail. The reasons for this lack of success can easily be traced to one of several causes: confusing monitoring with inventory, confusing monitoring with research or dependence on “standard methods.”

Confusing monitoring with inventory

Inventory can be described as a point-in-time assessment of the resource to determine location or condition and number. The types of information collected during an inventory can be identical to those collected during monitoring. A key difference is that inventory data are rarely related to a management goal or objective. Collecting this type of data is often justified as providing a “baseline” for later comparison to allow for change detection. However, the question “Are things different now than they were X years ago?” is facetious. Of course, things are different; things always change over time! The more appropriate questions are “How different are they?”, “Is this difference of ecological and management importance?” and “What is the cause of these changes?”

Confusing monitoring with research

A second common failing of monitoring efforts is equating monitoring with research. The goals of a research study are different from those of a monitoring project. Typically, monitoring addresses one of two questions: (1) Has the variable of interest changed by some defined magnitude (e.g., 20% decline over 5 years), or (2) Has that variable crossed some defined threshold (e.g., federal water quality standard)? Research usually tries to understand the causes of change—if such change occurs. These are more complicated questions, requiring greater sophistication in design, and thus larger expense. Too often, research, couched in terms of monitoring, repeatedly answers the same question because it is thought that monitoring needs to be focused on long-term data collection. Thus, its value decreases over time, as its relevance to current needs disappears.

For example, a common question when initiating a prescribed burning project is “What is the impact of prescribed fire on the rare plant species x?” This is a research question, and the parameters of interest might be survivorship, changes in reproduction, changes in vigor, and the like. To know that any differences detected pre- and post- burning are a result of the treatment, and not due to weather, a rigorous experiment needs to be implemented and data need to be collected in unburned (control) plots in addition to those plots in the burned area. The results of this experiment may, after five years of data collection, show that species x responds well to fire, with the survivorship and vigor of individuals being higher in the burned area than in the controls, and the reproduction rate is dramatically higher as well. The clear conclusion the fire management is beneficial to species x. The logical result would be to declare the research successful, and reallocation of efforts to different, or new, problems. Unfortunately, it is too often argued that even though we now know how the species responds to fire, data collection cannot be stopped because the original study was called a “monitoring” study and monitoring is a long-term effort. Similarly, these sorts of research studies are repeated, over and over, at many places because the original experimental design was couched as a monitoring study that becomes ossified as the accepted method. Thus, the experiment is repeated ad infinitum, and we rediscover that species x responds well to fire over and over again.

The appropriate response would be to acknowledge that research has shown that species x is fire dependent and the set management goals to ensure fires occur within some specified return interval. Monitoring would be based on some abundance objectives for species x; either some minimum number or some desired percent change over a specific period (e.g., a 20% increase in the number of flowering plants per hectare within 10 years).

Dependence on “standard methods”

A common failing of monitoring programs is to blindly follow some standard sampling protocol. Most often, such standard protocols have been developed with the goal of providing a common dataset across many sites. Because there is typically no common question among these installations, the protocol designers try to design sampling to capture the maximum amount of data possible, in the hope that when a question arises, there will be data available. Experience has shown that this hope is rarely, if ever, fulfilled. When a question does arise, invariably it turns out the data were collected in the wrong places, the wrong variable was measured, or the sampling protocol provided such low statistical power as to be worthless.

The keys to designing a monitoring program that is efficient, effective, and empowers adaptive management are simple: First, you need to know what you need to know. What is the question that needs to be answered? If there is no clearly defined question, the likelihood the data collected will provide value is nil. Some questions are easily articulated: Is the number of breeding pairs of x above our stated threshold? Has the spatial extent of prairie declined by more than 5 percent over the past decade? Has the habitat suitability index for grassland birds increased by 10 percent, on average, across the installation since 1990?

Monitoring questions about natural communities, or ecosystems, are more difficult to articulate so that they adequately address the conservation need. The common ecosystem descriptors (species composition, physiognomic structure, and function) rarely provide the information needed for management decisions. Documenting that arthropod species richness has declined by a few species, for example, doesn’t lead to obvious management actions.

Earlier, key ecological attributes were identified as those characteristics that must be maintained to ensure the integrity or viability of a conservation target. Threats to the targets manifest themselves as stresses on these attributes, and conservation actions should be focused on abating these threats. Effective monitoring should address changes in these threats, and the response in the key attributes.

That is obviously not a simple task and achieving success requires a deep understanding of the ecosystems of concern. As has been pointed out earlier, one way to achieve the necessary contextual understanding to accomplish useful and effective monitoring is through participation in an ecoregional study. In Colorado, Fort Carson's participation in the Central Shortgrass Ecoregional Assessment is an excellent example of where participation in an ecoregional study helped the installation focus its monitoring efforts of natural communities or ecosystems to make useful management decisions. Through that collaborative initiative, Fort Carson obtained ecological analyses, suggestions for priority areas, a monitoring framework, and ideas to help it address conservation management decisions.[15]

See subsection 8.5 in Chapter 8 for additional practical guidance on monitoring ecosystems and landscapes.

Conclusion

Science's curiosity about, study of, and understanding of environmental matters has grown prodigiously in recent years, as has its understanding of human effects on the natural world. We—scientists, policymakers, land managers, ordinary citizens—know better than ever that the actions we do and do not take can and will influence the globe on which we depend for life. This goes for natural resource managers on military installations as well as for homeowners who put chemicals on their lawns or people shopping for a new car.

Natural resource managers have a huge burden of responsibility, but they also have an enormous storehouse of useful knowledge that only recently has been assembled. Science has supplied them with information about ecosystems, species populations, habitat and communities, landscapes, monitoring, fragmentation, and hundreds of other ways to keep track of, and protect, the biodiversity in their care—and to do so while also serving the military mission.

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15 http://www.conservationgateway.org/ConservationPlanning/SettingPriorities/EcoregionalReports/Documents/CSP-20Final-20Report-202006.pdf

Resources

- The Landscape Toolbox, https://www.landscapetoolbox.org/ is managed by the USDA Jornada Research Institute. The Toolbox has a diversity of tools including access to the extremely useful Monitoring Manual for Grassland, Shrubland and Savanna Ecosystems. It also has many training videos explaining standard vegetation measurement protocols, guidance on sampling design, and access to several tools including the Database for Inventory, Monitoring and Assessment (DIMA) and several unique statistical tools.

- The Nature Conservancy's Conservation Gateway, http://conservationgateway.org. This site contains a diversity of information on conservation planning at the project, landscape, eco-regional, and major habitat scales. The gateway also provides access to several thousand documents on a diversity of conservation topics.

- Patuxent site and software. http://www.mbr-pwrc.usgs.gov/software.html.

- The U.S. Geological Survey's Patuxent Wildlife Research Center maintains a software library for resource managers. Most of the titles are for wildlife research and monitoring, but some (e.g., "Distance") can be utilized for estimating abundance of plants or physical phenomenon.

Ecological modeling:

- Vensim is a powerful, free software package that enables the development of state-transition and other stock/flow models. http://www.vensim.com.

- Stella is a state-of-the-art software for developing complex ecological models–the current model of the Chesapeake Bay ecosystem was developed using Stella. http://www.iseesystems.com/softwares/Education/StellaSoftware.aspx

- Miradi is an open-source conservation planning software. It also provides a "Rosetta stone" document that compares the conservation planning protocols developed by all the large conservation organizations. https://www.miradi.org

- NatureServe. www.natureserve.org.

- NatureServe, the publisher of this handbook, is, among other things, a consortium of state programs. This NatureServe Explorer website (https://explorer.natureserve.org/) provides a diversity of information on species, natural communities, and ecosystems, including guidance on assessing species' viability and ecosystem integrity.

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3. Challenges at the Nexus of Science and Policy

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Introduction

The conservation and enhancement of biological diversity on the public's military lands have emerged as significant components of the Department of Defense's (DoD) overall environmental and natural resources management programs. This is due to a variety of influences, some from within the DoD and others directed by Congress. This short chapter provides a summary of three challenges that DoD natural resource managers will undoubtedly face in their work and why effective management around these and other issues require an understanding and balanced application of relevant science and policy topics.

Threats to patterns and processes at the landscape and ecosystem scale

An important trend in conservation science over the last three decades in particular has been the steady increase in our understanding of how ecosystem processes depend on biodiversity and other biophysical structures and patterns and how these patterns and the processes they sustain change over time. To have any chance of sustaining ecosystem processes, managers must evaluate patterns at the landscape scale.

From an ecological and conservation standpoint, landscapes are usually defined as heterogeneous land area[s] composed of a cluster of interacting ecosystems that is repeated throughout (Forman and Godron 1986). In other words, a landscape has both diversity but also coherency and repetition. Impacts to these patterns can alter ecosystem processes, sometimes to a point of state change where the ability to sustain historic processes is permanently lost.

Encroachment

In the context of DoD operations, encroachment is often defined exclusively as the cumulative result of all outside influences that inhibit normal military training, testing and operations. While the military's primary objective might be to safeguard operations and readiness, the types of encroachment that DoD natural resource managers must account for in their planning and management activities can take many forms and work in several directions.

From a biodiversity and environmental protection perspective, the loss of natural habitats through development on areas adjacent to military installations can negatively impact the biodiversity on military lands. Encroachment may contribute to the loss of migration corridors for wildlife, the reduction in size of critical natural populations of imperiled species and their critical habitats, increased air and water pollution that may negatively impact native species, and many other potential direct and indirect effects. Military testing and training can impact non-military lands and waters (wilderness areas, national parks, ocean basins) far from installations. Examples include Air Force overflights or low-level training in wilderness areas and national wildlife refuges and impacts to marine life by Navy SONAR operations and ship shock testing in the open oceans.

From the standpoint of civilian communities adjacent to military installations, the expansion of no-development zones, noise, and other disruptions driven by military operations are often seen as encroachment upon their property and interests. Military impacts such as overflights, artillery noise, interference with radio spectra, or the need for safety buffer zones around impact areas and unexploded ordnance (UXO) are some of the more important aspects of military operations that are incompatible with civilian development near military ranges.

Increasing human population and development and a finite land base will certainly ensure that encroachment will remain a major issue for the DoD and that natural resource managers will need an understanding of related science and policy issues to design and execute plans that prevent, minimize, and/or mitigate related impacts on natural and human communities. Much of the basis for understanding and managing encroachment is provided in Chapter 8 (Landscape and Ecosystem Management).

Climate change

> "Today, no nation can find lasting security without addressing the climate crisis. We face all kinds of threats in our line of work, but few of them truly deserve to be called existential. The climate crisis does. Climate change is making the world more unsafe and we need to act."
>
> - Secretary of Defense Lloyd J. Austin in an address to the Leader's Summit on Climate, 22 April, 2021.

Global temperature rise since the late 19th century—most of it concentrated in the last 40 year--has led to historically high temperatures with 2016 and 2020 tied for the warmest year on record (NASA 2021). Climate change impacts such as increased drought and flooding are happening with greater frequency while sea level rise and polar ice melt are increasing in both pace and and magnitude (Reidmiller et al. 2018).

Climate change is already causing significant shifts in the distribution of species and in distribution and structure ecosystems (Pecl et al 2017). In many cases, these shifts are already irreversible—with increasing ecosystem shift predicted in the coming years (Grimm et al. 2013). Using a “climate envelope” approach that correlates species' occurrences with climatic and environmental variables Zarnetske et al. (2012) predicted that by 2050, 15 to 37% of species will be faced with extinction.

Increasingly, the complex management challenges posed by the interplay of climate change, ecosystem function, and land use are seen as a challenge that will require efforts across traditional ecological, conservation, and social disciplines (Bonebrake et al. 2018). To succeed in this context, natural resource managers of DoD lands will require both accurate and current scientific information and a knowledge of the wider environmental and social landscape within which DoD installations are embedded. The recent resource, ‘Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Considerations into Integrated Natural Resource Management Plans’ (Stein et al. 2019) (https://www.denix.osd.mil/nr/dodadaptationguide/) represents a central reference for understanding and addressing the many challenges of climate change on DoD lands.

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Part II. Conservation in Practice in the DoD Context

4. Laws, Policies, and Programs Related to Conservation and Natural Resource Management on and Around DoD Lands

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Introduction

This first section of this chapter introduces the most significant legislation enacted during the past quarter-century related to the management of natural resources located on military lands and waters, as well as resources located on public or private lands and waters affected by military activities. While much of this legislation was requested by the Department of Defense (DoD), some originated with Congress itself.

Sikes Act

Enacted in 1960, the Sikes Act provides the authority and defines the responsibilities to facilitate "effectual planning, development, maintenance, and coordination of wildlife, fish, and game conservation and rehabilitation in military reservations." The act is named after Rep. Robert L.F. Sikes, Democrat representing Northwest Florida, home to Eglin AFB and other major DoD installations. The full text of the act may be found at https://www.fws.gov/endangered/esa-library/pdf/2004SikesAct%20NMFWA.pdf.

In its original form, the Sikes Act mainly addressed public access to military lands for hunting and fishing activities. Over the years the act has been significantly strengthened, and its scope expanded, to the point that it now represents a comprehensive law mandating the conservation of all aspects of natural resources on military lands.

Sikes Act amendments (1997)—The most significant set of amendments to the Sikes Act, collectively known as the Sikes Act Improvement Act of 1997, was enacted with the strong support of the U.S. Fish and Wildlife Service (FWS) and the Association of Fish and Wildlife Agencies (representing state fish and game agencies). Major provisions of the Sikes Act Improvement Act of 1997 include:

- There is a mandatory requirement for all DoD installations with natural resources to prepare a comprehensive Integrated Natural Resources Management Plan (INRMP).
- The INRMP must be prepared in cooperation with FWS and the pertinent state fish and game agency.
- Public comment is required on the INRMP.
- The INRMP must be implemented.

Subsequent modifications to the Sikes Act, mainly through provisions specified in the Defense Authorization Act, have addressed a number of issues, ranging from providing disabled veterans with access to hunting and fishing programs on military, to control of invasive species, and compliance with the Endangered Species Act. The more important of these provisions are discussed below.

Endangered Species Act (ESA)

Compliance with the ESA has long been a major component of the DoD's environmental programs. For that reason, there was considerable concern when the FWS began a court-ordered effort to designate critical habitat for all federally listed species. The concern in the DoD with the new FWS effort was that declaring critical habitat would add a new administrative burden on military installations with no added benefit to listed species. The DoD argued that it was already providing extensive protection to listed species through its formal consultations with the FWS and the conservation measures specified in installation INRMPs. It therefore argued that designating military land as critical habitat would only add an additional compliance and consultation burden on the DoD while not enhancing protection for listed species.

Although the DoD endangered species policy is well established in DoD Directive 4715.3 and the individual services natural resources directives, recent legislative initiatives regarding the designation of critical habitat have necessitated some modifications to the DoD policy which are yet to be formalized. However, the Army has prepared specific guidance regarding the designation of critical habitat under the ESA that addresses the issue of using the existence of an installation INRMP to preclude the designation of critical habitat, as discussed below.

The DoD got relief from the provision in the FY 2004 Defense Authorization Act (Section 318). This legislation granted the FWS specific authority to exempt DoD lands from the designation of critical habitat provided:

- A comprehensive and approved INRMP was in effect.
- The INRMP specifically addressed the conservation of the species under consideration.

- The INRMP was implemented.[16]

Migratory Bird Treaty Act

Although the DoD has a long history of positive contributions to the conservation of migratory birds (http://www.dodpif.org/), the Navy was sued successfully regarding the "unintentional take" of birds at a bombing range in the Western Pacific on the island of Farallon de Medinilla. The Migratory Bird Treaty Act has many provisions for the regulated "intentional taking" of migratory birds. Examples include waterfowl hunting, depredation of nuisance species, or birds that pose a safety hazard. However, the Act has no provision for the "unintentional taking" of migratory birds. That is, if birds are taken by accident or in conjunction with some activity (e.g. military operations) whose primary purpose is not the taking of birds, the law has no provision to issue a permit for such activities. Hence, there would be no legal way to conduct military operations if any birds were taken in the process. To address this problem and the legal decision against it at Farallon de Medinilla, the Navy sought and achieved legislative relief regarding "unintentional take" during military readiness operations in the FY 03 Defense Authorization Act. A Final Rule reflecting this was published on 28 February 2007 in the Federal Register.[17]

This change allows the military to obtain permits for the "unintentional take" of a migratory bird if it is in support of a military readiness operation. The specific details of this new procedure are spelled out in a memorandum of understanding between the DoD and FWS, as required by E.O. 13186 Migratory Birds that was signed on 31 July 2006. These procedures contain significant safeguards to ensure that the taking of birds is minimized when the new rule is used and that conservation measures are employed to compensate for the losses that may occur.[18]

Marine Mammal Protection Act

The Navy actively sought and achieved through the 2004 Defense Authorization Act (Section 319), a clarification of the definition of "take" under the Marine Mammal Protection Act. Specifically, this provision modified the meaning of Level B Harassment of a marine mammal when caused by military activities. The net result of this change was to increase slightly the harassment threshold and thereby reduce the number of occasions in which the military services would need to consult the National Marine Fisheries Service regarding their testing or training operations.

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[16] https://www.congress.gov/bill/108th-congress/house-bill/1588/text

[17] https://www.federalregister.gov/documents/2011/06/03/2011-13807/migratory-birds-take-of-migratory-birds-by-the-armed-forces

[18] https://www.law.cornell.edu/cfr/text/50/21.15

(http://www.dod.mil/dodgc/olc/docs/2004NDAA.pdf).

Box 4.1: Harassment

Under the Marine Mammal Protection Act, “harassment” is one component of a larger prohibition known as a “taking” and consists of two levels:

Level A Harassment: Action with the potential to injure marine mammals or marine mammal stock in the wild (e.g. ship strike, underwater explosion).

Level B Harassment: Action with the potential to disturb marine mammals or marine mammal stock in the wild by causing disruption of behavioral patterns. (e.g. sonar, aircraft overflight).

Major issues at the nexus of conservation and policy

This section notes current legal, policy, and programmatic context for the major conservation/policy nexus issues presented in the preceding chapter.

Ecosystem management and biodiversity conservation

The DoD formally established a policy for an ecosystem approach to natural resources management and for the conservation of biological diversity in its 1996 Conservation Instruction (DoDI 4715.3) with current policy being consolidated in DoDI 4715.03 with changes applied in August 2018.[19] This and earlier versions of the DoD Biodiversity Handbook informally reinforce that policy. The DoD Policy regarding ecosystem management and biodiversity conservation was derived largely from the recommendations of the “Keystone Center Policy Dialogue on a Department of Defense (DoD) Biodiversity Management Strategy” (Keystone Center, 1996). The Keystone Center, a private non-profit organization, helps individuals and organizations approach environmental and scientific dilemmas and disagreements creatively and proactively. The center assisted the DoD in addressing the issue of biodiversity conservation through a series of dialogues involving the military, the academic community, environmental organizations, and concerned individuals.[20]

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[19] https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/471503p.pdf?ver=2019-02-28-120916-070

[20] https://apps.dtic.mil/sti/pdfs/ADA597063.pdf

The key elements of DoDI 4715.03 related to ecosystem management include the following goals, principles, and guidelines:

The goal of ecosystem-based management is to ensure that military lands support present and future training and testing requirements while preserving, improving, and enhancing ecosystem integrity. Over the long term, that approach shall maintain and improve the sustainability and biological diversity of terrestrial and aquatic (including marine) ecosystems while supporting sustainable economies, human use, and the environment required for realistic military training operations.

Principles and guidelines for ecosystem management:

- Maintain and improve the sustainability and native biodiversity of ecosystems.
- Administer with consideration of ecological units and timeframes.
- Support sustainable human activities.
- Develop a vision of ecosystem health.
- Develop priorities and reconcile conflicts.
- Develop coordinated approaches to work toward ecosystem health.
- Involve the military operational community early in the planning process.
- Develop a detailed ecosystem management implementation strategy for installation lands and other programs.
- Meet regularly with regional stakeholders (e.g., state, tribal, and local governments; nongovernmental entities; private landowners; and the public) to discuss issues and to work towards common goals.
- Incorporate ecosystem management goals into strategic, financial, and program planning and design budgets to meet the goals and objectives of the ecosystem management implementation strategy.
- Seek to prevent undesirable duplication of effort, minimize inconsistencies, and create efficiencies in programs affecting ecosystems.
- Rely on the best science and data available.
- Use benchmarks to monitor and evaluate outcomes.
- Use adaptive management.
- Implement ecosystem management through installation plans and programs.

Biodiversity conservation on DoD lands and waters shall be promoted when consistent with the mission and practicable to achieve the following goals:

- Maintain or restore remaining native ecosystem types across their natural range of variation.
- Maintain or reestablish viable populations of all native species in an installation's areas of natural habitat, when practical.
- Maintain evolutionary and ecological processes, such as disturbance regimes, hydrological processes, and nutrient cycles.
- Manage over sufficiently long-time periods for changing system dynamics.
- Accommodate human use in those guidelines.

Each of the military services has incorporated policies regarding ecosystem management and biodiversity conservation into their natural resources directives. These policies are subject to periodic review and revision because of their relationship to so many other natural resources management issues (e.g. sustainability, encroachment, etc.).

Programs that facilitate management at landscape and ecosystem scales

Though most of the following are introduced in the introductory Chapter 1 and discussed in greater detail in Chapter 6 (Partnerships), it is important to understand how these key programs encourage and facilitate a larger perspective on environmental management. As management scales increase, so does the complexity of the associated challenges to the manager. These programs can help natural resource managers enhance conservation and mission readiness at these larger scales.

Readiness and Environmental Protection Initiative (REPI)—the REPI program is DoD’s flagship program to facilitate a landscape-scale management perspective in and around DoD lands with the objective of combating encroachment that can impact military training, testing, and operations. By facilitating buffer partnerships among the military services, private conservation groups, and state and local governments, the REPI program protects these military missions by helping remove or avoid land-use conflicts near installations and addressing regulatory restrictions that inhibit military activities. The REPI program is administered by the Office of the Secretary of Defense (OSD). See Chapter 6 (Partnerships) for additional details on this program.

Sentinel Landscapes—Initiated in 2013 by the DoD, Department of Agriculture, and Department of the Interior, the Sentinel Landscape Partnership is a coalition of federal agencies, state and local governments, and non-governmental organizations that engages private landowners in advancing sustainable land use practices around DoD lands. The mission of the partnership is to:

- Strengthen military readiness.
- Conserve natural resources.
- Foster agricultural and forestry economies, and
- Increase climate change resilience.

The Army Compatible Use Buffer Program (ACUB)—The ACUB program empowers Army installations to work with partners to protect habitat and buffer lands used for training without acquiring new land under Army ownership. The ACUB program facilitates mutually beneficial use of land with partners to preserve high-value habitat and limit development of land near installations. Establishing buffer areas around Army installations limits the effects of encroachment and therefore safeguards the installation's mission. (https://aec.army.mil/index.php/conserve/ACUB).

Base Realignment and Closure (BRAC)—The Base Realignment and Closure (BRAC) process, though not employed since 2005, will receive fresh funding in 2021. This program has had profound effects on both the military and surrounding civilian and natural communities, since it has involved wide-ranging changes to bases, the many people associated with those bases, and of course the environment in and around these DoD lands. BRAC has been employed five times since the enactment of the Defense Realignment and Closure Act in 1990—most recently in 2005. The process has closed or realigned hundreds of installations, some with significant natural resources.

Some military installations closed through the BRAC process have been transferred to other land management agencies because of their exceptional natural and cultural resources. Among those are the U.S. Army's Presidio of San Francisco, California (transferred to the National Park Service); the U.S. Army's Jefferson Proving Ground, Indiana; Fort Ord, California, and the North Tract of Fort Meade, Maryland (all transferred to the FWS); the U.S. Navy's Midway Atoll (transferred to the FWS), and the U.S. Air Force's Pease Air Force Base, New Hampshire (transferred to the FWS).

Each military service has developed policies and procedures for assessing the environmental and natural resources conditions on installations being considered for closure or realignment. These assessments typically consider the occurrence of rare, threatened, or endangered species and the general level of biodiversity present (https://www.acq.osd.mil/brac/).

Encroachment

Some of the complex issues around encroachment were presented in Chapters 1 and 3. In response to these challenges, numerous policies have been developed by the DoD and others to address and mitigate the many impacts of encroachment.

All the military services focus on community partnering and intergovernmental planning to achieve compatible land use and zoning to protect ever-evolving management needs. They integrate these activities as appropriate with such programs as the Air Installations Compatible Use Zones (AICUZ) program (http://tinyurl.com/33xcpt) and the Joint Land Use Study (JLUS) Program (http://tinyurl.com/3yfaoj).

For the past several years, this partnership approach has largely been accomplished through efforts to comply with the provisions of Section 2684a of the FY2003 Defense Authorization Act, 10 USC 2684a. The most conspicuous element of this effort has been the establishment of the Readiness and Environmental Protection Initiative (REPI), a component of the Sustainable Range Initiative.

The Army began the first formal program to address encroachment in 1995 at Fort Bragg, N.C., where it worked with stakeholders in and around the installation to develop the Fort Bragg Private Land Initiative (also called the North Carolina Sandhills Conservation Partnership) as a way to work cooperatively to conserve private lands to help restore the red-cockaded woodpecker, a federally listed endangered species. This effort led to the Army's partnering with The Nature Conservancy and other stakeholders to buy lands or interests from willing owners. The lands were then used as additional off-base habitat for the bird, while providing open space for the community and a buffer from encroachment for the installation. The results were that the Army could once again use training lands that had been previously set aside exclusively to protect woodpecker habitat, habitat for the bird was expanded, and open space was preserved from encroachment around Fort Bragg, thus reducing potential conflicts with military activities. In 2005, Fort Bragg reached a woodpecker population size of 436 groups, an increase from 350 in 2000, and exceeded the population recovery size dictated by the Endangered Species Act. (See https://www.denix.osd.mil/denix/Public/Library/NCR/Documents/RCW-fact-sheet-Aug06.pdf)

From its highly successful initiative at Fort Bragg, the Army developed the Army Compatible Use Buffer Program (ACUB) that allows for the establishment of conservation easements and other strategies to protect its training ranges from encroachment. (http://www.sustainability.army.mil/tools/programtools_acub.cfm). Through the ACUB program, the Army enters into cooperative agreements with partners to purchase land or interests in the land and/or water rights from willing sellers as part of a comprehensive approach to protect its testing and training requirements. Under these arrangements, cost-sharing agreements are individually negotiated between the Army and the partners.

Building on DoD's REPI guidance, the Navy and Marine Corps have also addressed encroachment issues in the past several years through what they term Encroachment Partnering (EP) Programs, part of an overall Encroachment Control Program that develops encroachment action or control plans that delineate short, medium, and long-term strategies for each installation. The Department of the Navy's practice has been to acquire a recordable interest in property in the form of a restrictive use or conservation easement or deed covenants similar to a real estate civil easement, in which one party grants permission for a road or utility right-of-way.

The Air Force, probably the military service least impacted directly by infringement, has only recently begun to address the encroachment issues, primarily by focusing on community partnering and intergovernmental planning to achieve compatible land use and zoning to protect ever-evolving airspace management needs.

The authority in 10 USC 2684a represents a significant step forward in encouraging open communication and collaboration between the military and a wide array of stakeholders, leading to successful conservation/compatibility partnerships that are focused on common objectives. These partnerships allow DoD to make clear-cut gains in achieving conservation and protecting the military mission by leveraging funds to accomplish the protection of vital lands and habitats.

Some of the most significant recent environmental and readiness legislation includes efforts to fund conservation easements adjacent to military lands. As discussed above, the DoD and the military services worked with Congress to define a statutory authority to address encroachment. The result was that Congress, in Section 2811 of the National Defense Authorization Act for FY 2003, provided the military with an important new tool for using partnerships to prevent incompatible land use. This new authority allowed DoD to enter into agreements with private conservation organizations or state and local governments to cost-share acquisition of land or interests in land to preserve valuable habitat and limit incompatible land use. These partnerships allow DoD to leverage funds to make clear-cut gains in achieving conservation and protecting the military mission.

Climate change policy in the DoD

In 2016, the DoD issued directive 4715.21 Climate Change Adaptation and Resilience.[21] This directive, "…establishes policy and assigns responsibilities to provide the DoD with the resources necessary to assess and manage risks associated with the impacts of climate change. This involves deliberate preparation, close cooperation, and coordinated planning by the DoD to:

- Facilitate federal, State, local, tribal, private sector, and nonprofit sector efforts to improve climate preparedness and resilience, and to implement the 2014 DoD Climate Change Adaptation Roadmap.

[21] https://dod.defense.gov/Portals/1/Documents/pubs/471521p.pdf

- Help safeguard U.S. economy, infrastructure, environment, and natural resources.
- Provide for the continuity of DoD operations, military services, and programs."

There is no question that climate change poses a major challenge to national security and DoD facilities. In early 2021, shortly after President Biden signed a series of executive orders targeting the climate crises, Defense Secretary Lloyd Austin confirmed that the Pentagon will feature the issue as part of its future National Defense Strategy.[22]

While these policies focus on mission readiness, the DoD has also embraced guidance to improve natural resource management on DoD installations. The comprehensive resource, 'Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Considerations into Integrated Natural Resource Management Plans' (Stein et al. 2019) is a significant milestone for climate change planning and, if applied effectively, will mean more effective INRMPs and installation management going forward.

Other issues of conservation significance and the policies which govern them

Virtually all of the following issues are closely intertwined with the topics above and most refer the reader to additional information and guidance found throughout this manual.

Invasive species

In some cases, invasive species directly affect military training operations. On almost every DoD installation—as elsewhere—invasive species are having a deleterious effect on the natural resources. Military invasive species issues involve efforts to control the introduction or spread of invasive species due to military operations (e.g. return shipments to the U.S. of military equipment from overseas deployments, discharge of ballast water by Navy vessels in U.S. ports, etc.) to the control of invasive species on military lands. Efforts to deal with this issue are being addressed primarily through the DoD Armed Forces Pest Management Board and by the individual services' natural resources guidance.[23]

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[22] https://www.defensenews.com/pentagon/2021/01/27/climate-change-is-now-a-national-security-priority-for-the-pentagon/

[23] https://www.acq.osd.mil/eie/afpmb/

The DoD has issued guidance, via a memorandum for the implementation of Executive Order 13112, Invasive Species.[24]

The FY 2004 Defense Authorization Act (Section 311-c) also contained legislation establishing a pilot program for the control of invasive species on military lands in Guam. This effort is mainly focused on the control of the brown tree snake and enhances earlier legislative efforts to address this serious issue.[25]

Chapter 10 of this handbook provides a more in-depth look at invasive species issues and management strategies on DoD lands.

Wetlands regulations

The U.S. Army Corps of Engineers defines wetlands as "those areas that are inundated or saturated with ground or surface water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions." Wetlands are an important natural system because of the diverse biological and hydrologic functions they perform. These functions could include water quality improvement, groundwater recharge, pollution treatment, nutrient cycling, provision of wildlife habitat and niches for unique flora and fauna, stormwater storage, and erosion protection.

Wetlands are protected as a subset of the "waters of the United States" under Section 404 of the Clean Water Act (CWA). The term "waters of the United States" has broad meaning under the CWA and incorporates deepwater aquatic habitats and special aquatic habitats (including wetlands). "Jurisdictional" waters of the United States are areas regulated under the CWA and could also include coastal and inland waters, lakes, rivers, ponds, streams, intermittent streams, vernal pools, and "other" waters that if degraded or destroyed could affect interstate commerce.

Section 404 of the CWA authorizes the Secretary of the Army, acting through the Chief of Engineers, to issue or deny permits for the discharge of dredged or fill materials into the waters of the United States, including wetlands. In addition, Section 404 of the CWA also grants states with sufficient resources the right to assume these responsibilities.

Section 401 of the CWA gives the state board and regional boards the authority to regulate, through water quality certification, any proposed federally permitted activity that might result in a discharge to water bodies, including wetlands.

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[24] https://www.invasivespeciesinfo.gov/executive-order-13112

[25] See Chapter 10 for more on invasive species and efforts to control them.

Furthermore, wetlands are protected under Executive Order 11990, Protection of Wetlands (43 FR 6030) (https://www.ecfr.gov/cgi-bin/text-idx?node=pt18.2.725&rgn=div5), the purpose of which is to reduce adverse impacts associated with the destruction or modification of wetlands. The secretary of each military service has established procedures to redelegate authority for the protection of wetlands to a lower administrative level, typically at the major operational command. The commander at that level, typically serving as chair of command's Environmental Protection Committee, must sign a Finding of No Practicable Alternative (FONPA) before any action within a federally designated wetland may proceed. In preparing a FONPA, the military unit must consider alternatives that will satisfy justified program requirements, meet technology standards, are cost-effective, do not result in unreasonable adverse environmental impacts, and other pertinent factors. When the practicality of alternatives has been fully assessed, only then should a statement regarding the FONPA be made into the associated FONSI or Record of Decision (RoD).

As a result of the previously cited federal and state regulations, the military services are responsible for identifying and locating jurisdictional waters of the United States (including wetlands) occurring on military lands where these resources have the potential to be impacted by military mission activities. Such impacts could include construction of roads, buildings, runways, taxiways, navigation aids, and other pertinent structures or activities as simple as culvert crossings of small intermittent streams, riprap placement in stream channels to curb accelerated erosion, and incidental fill and grading of wet depressions.

Water conservation

Particularly at installations in the Southwest, water conservation has emerged as a significant policy issue. Water conservation issues, such as at Fort Huachuca, Arizona, Fort Carson, Colorado, and the military installations in the San Antonio, Texas, area, are often linked to a number of other environmental issues (e.g. Endangered Species Act compliance, encroachment of civilian housing, etc.). To date, these issues have been addressed locally on a case-by-case manner without a consistent DoD or individual service policy.

Law enforcement

The Sikes Act mandates that natural resources law enforcement be provided on military lands, and the DoD has developed very general law enforcement policy in DoD Directive 4715.3. However, comprehensive DoD law enforcement policy is lacking and each military service has historically addressed the subject individually on an installation-by-installation basis. This has included a range of law enforcement options ranging from employment of civilian game wardens, military police, or combinations of civilian game wardens and military police.

In 2013, the DoD established the Conservation Law Enforcement Program (CLEP) (DoD 2013). The purpose of this program is to provide a general framework for law enforcement across the military services including specifying authority, powers, and jurisdiction of DoD natural resource law enforcement. CLEP also provides job descriptions, training objectives, and other guidance for coordinating, training and staffing natural resource law enforcement across all military installations.

Cooperation conservation efforts

It has long been DoD policy to encourage cooperation on natural resources management issues with federal organizations, states, local governments, non-governmental organizations, and individuals to maintain and improve natural resources, as outlined in DoD Directive 4715.3. Prior to the enactment of 10 USC 2684a, discussed above in the Encroachment Section, the Sikes Act was used as the primary authority for the Secretary of Defense to enter into cooperative agreements. However, this authority was almost entirely directed to the protection of resources within the boundaries of DoD installations. The authority of 10 USC 2684a allows for cooperative conservation efforts through the acquisition of land or easements in the vicinity of military installations and ranges, thus adding a valuable flexibility to wildlife protection efforts. Finally, Executive Order 13352, Cooperative Conservation, specifically directs federal agencies to develop cooperative conservation programs (https://www.govinfo.gov/content/pkg/CFR-2005-title3-vol1/pdf/CFR-2005-title3-vol1-eo13352.pdf).

Over the years, cooperative conservation efforts with federal and state agencies, nongovernmental organizations, universities, and museums have provided many opportunities for the DoD to obtain invaluable, cost-effective research and other services in support of its natural resources conservation programs. With the authority of 10 USC2684a, many new cooperative agreements are being established that help to enhance off-base habitat and to ease encroachment problems in the vicinity of military installations. Additional programs and policies related to cooperative conservation efforts are presented in detail in Chapter 6 (Partnerships).

Public access to military lands

Public access to military lands for recreational purposes has long been a requirement of the Sikes Act. The Defense Authorization Act of 1999 expanded this requirement to specifically encourage access to hunting, fishing, and other outdoor recreation opportunities for disabled veterans.

However, DoD policy has always stated that the local military commander has the authority to decide the extent of public access to his or her installation, based on security and safety considerations. And, following the events of 11 September 2001, public access has been significantly reduced to most military installations. Consequently, no DoD formal policy exists for public access to military bases and ranges, and public access is handled mainly on a case-by-case basis at individual installations.

Mission sustainability

Ever-increasing demands on limited land resources, especially for the Army and Marine Corps, have resulted in new concerns about the sustainability of the military land base. This is attributable to the increasing demands on the land base by larger and more complex military equipment, along with the employment of new training strategies. Also, the loss of some large training areas, such as the Navy's Vieques Training Range in Puerto Rico, have further emphasized the need for ensuring the sustainability of remaining military lands. And the many new operational constraints imposed by encroachment further threaten the sustainability of military testing and training lands.

The DoD has developed a comprehensive plan as part of its evolving Sustainable Range Initiative (SRI) to ensure the sustainability of military ranges and installations while simultaneously protecting the environment and ensuring that realistic training lands will be available in perpetuity. The DoD's annual Sustainable Ranges Report to Congress describes the importance of range sustainability to the DoD and the specific steps it is taking to address this critical issue (https://www.denix.osd.mil/sri/policy/reports/index.html).

The overarching policy for this Sustainable Range Initiative is presented in DoD Directive 3200.15, Sustainment of Ranges and Operating Areas, signed in January 2003. The Army has taken the most structured and significant strides to address the practical aspects of long-term sustainability of its lands through the establishment in 1984 of its Integrated Training Area Management (ITAM) program. This effort established long-term monitoring and assessment protocols for Army training lands with a view to ensuring their sustainability. Only in very limited cases has the ITAM program been employed in the other military services.

Resources

Landscape and Ecosystem Management

- The Landscape Toolbox USDA Jornada Research Institute: https://www.landscapetoolbox.org/
- Ecosystem-based Management Tools Network: https://www.octogroup.org/ebmTools/

Climate Change

- Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Considerations into Integrated Natural Resource

Management Plans: https://www.nwf.org/Educational-Resources/Reports/2019/05-01-19-DoD-Climate-Adaptation

- DoD Climate Assessment Tool: https://media.defense.gov/2021/Apr/05/2002614579/-1/-1/0/DOD-CLIMATE-ASSESSMENT-TOOL.PDF
- Climate Adaptation Knowledge Exchange: https://www.cakex.org/
- Data Basin: https://databasin.org/

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5. The Integrated Natural Resources Management Plan: Foundations and Key Topics

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Introduction

This chapter describes the purpose of Integrated Natural Resources Management Plans (INRMPs), policies and other guidance that inform their content and structure, and describes some best management practices for developing effective INRMPs.

INRMPs are based on the principles of ecosystem management. They establish goals and objectives, describe how to manage natural resources, allow for multipurpose uses of those resources, and define public access—all while ensuring no net loss in the capability of an installation to support its military testing and training mission. They are the clearing house for everything natural resource-related on the installation. They integrate other information and plans such as installation master plans and range and training land plans; recreation; natural resources compliance commitments; and partnerships, as well as the Integrated Training Area Management (ITAM) program (Army only, several exceptions) in support of the Army's Sustainable Range Program.

There are currently over 380 INRMPS being implemented across the Department of Defense (DoD) military services on more than 25 million acres of land managed by the military (Orndorff 2020) (Figure 5.1). The INRMP integrates all traditional elements of natural resources management related to species, habitats, and environmental quality. The process also considers military mission requirements, installation master planning, environmental planning, and outdoor recreation. To address installation requirements and regional issues, INRMPs involve appropriate stakeholders, thereby providing for more efficient and effective management of natural resources on a landscape-scale, all while ensuring that military readiness is sustained.

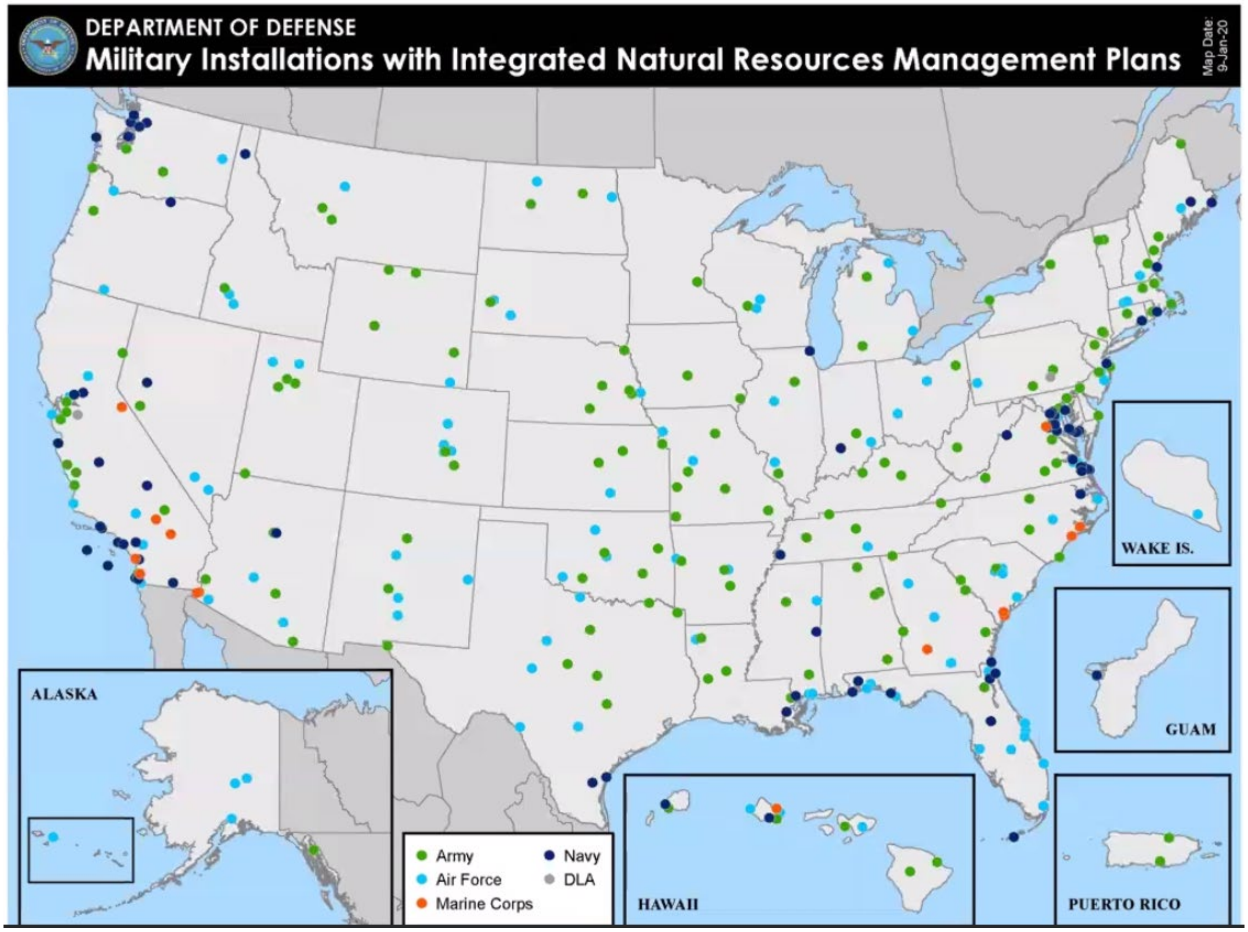

Figure 5.1. Locations of military installations with integrated natural resources management plans (INRMPS), by Military Service (Orndorff 2020).

INRMP drivers and underpinnings

Policy and guidance

Congress established the Sikes Act (16 U.S.C. 670a- 670o) in 1960 to ensure that DoD conserves and protects the natural resources they use. Because military lands often are protected from human access and impact, they contain some of our nation's most significant remaining large tracts of valuable natural resources. In 1997, Congress amended the Sikes Act to require DoD to develop and implement (i.e., fund) Integrated Natural Resources Management Plans (INRMPs) to outline how each military installation with significant natural resources will manage those resources. In conjunction with the discussion of INRMPs in DoDI 4715.3, Environmental Conservation Program (1996)[26], the stage was set to fully implement the new requirements. The 1997 amendments also required that INRMPs be prepared in cooperation with the appropriate state fish and game/natural resources agency and the U.S. Fish and Wildlife Service (FWS), that they be subject to public review and comment, that they emphasize natural resources more comprehensively than only fish and wildlife, that they include specific management goals and objectives (and associated timeframes), and that they undergo a review process not less than every five years. Additional details related to policy, guidance and their implementation are in the sections that follow.

The DoD developed guidance on the development and implementation of INRMPs via official memoranda and provides INRMP guides, handbooks, and other development tools, including:

- 10 Oct 2002—Memorandum providing policy on INRMP coordination, reporting, and implementation.
- August 2005—“Best Practices for Integrated Natural Resources Management (INRMP) Implementation” (Gibb 2005a, 2005b). This national-level, Legacy-funded study interviewed a number of natural resources managers and reviewed INRMPs representing the Army, Navy, Marine Corps, and Air Force. Among other outcomes, the study developed recommendations across 11 areas of interest relevant to best practices and effective INRMP implementation. Overall, the study found the INRMP document and its associated process—with emphasis on ecosystem management, partnering, and coordination—directly benefit military trainers and play a key role in management and conservation of the nation’s natural resources (Gibb 2005a).
- September 2005—“Resources for INRMP Implementation. A Handbook for the DoD Natural Resources Managers.”
- 14 August 2006—Memorandum outlining an INRMP template for new and revised INRMPs.
- March 2011—DoD Instruction 4715.03, Natural Resources Conservation Program. (Incorporating Change 2, August 2018.
- July 2013—Memorandum of Understanding (MOU) between the DoD, FWS and the Association of Fish and Wildlife Agencies (AFWA) for a Cooperative Integrated Natural Resources Management Program. This MOU furthers a cooperative relationship between the participating agencies in preparing,

[26] The most recent version is DoDI 4715.03

reviewing, revising, updating and implementing INRMPs for military installations.

- November 2013—DoD Manual 4715.03, Integrated Natural Resources Management Plan (INRMP) Implementation Manual. This manual establishes implementing guidance to manage DoD's natural resources for mission and stewardship purposes. (Incorporating Change 2, August 2018)
- July 2015—Memorandum by the Deputy Assistant Secretary of Defense Environment, Safety and Occupational Health: Mutual Department of Defense & FWS Guidelines for Streamlined Review of Integrated Natural Resources Management Plan Updates. The guidelines are intended to clarify and describe the process for reviewing and concurring on updates to existing INRMPs, as described in the Tripartite Agency MOU signed in July 2013.

Each military service has developed specific policy guidance for INRMP implementation in its individual natural resources directives and through other guidance. The most recent service guidance is shown below:

Army

- Army Regulation 200-1, Environmental Protection and Enhancement (December 2007)

Navy

- OPNAVINST 5090.1E, Environmental Readiness Program Manual, OPNAV-M 5090.1 (September 2019)

U.S. Marine Corps

- “USMC Handbook for Preparing, Revising and Implementing Integrated Natural Resources Management Plans on Marine Corp Installations” (October 2007)
- Environmental Compliance and Protection Program, Volume II, Marine Corps Order 5090.2-Vol II, June 2018.

U.S. Air Force

- Air Force Instruction 32-7064, Integrated Natural Resources Management, Incorporating Change 3, August 2013.

These policies are subject to periodic review and revision because of their relationship to so many other natural resources management issues (e.g. sustainability, encroachment, etc.), legislation and policies.

INRMPs are developed and implemented in response to a variety of requirements, but DoD biodiversity conservation efforts often exceed those requirements, or are adjusted through cooperation with regulators. For example, species protection, recovery and management activities on installations are often embedded within larger habitat or ecosystem-scale efforts for not only a single species, but for multiple species that may rely on similar habitats or are impacted by similar threats or stressors. Furthermore, the delisting (no longer threatened or endangered) or downlisting (from endangered to threatened) of a species does not necessarily lead to downscaling in recovery or management activities for that species. In some cases, aspects of rare species management may continue as before. A recent example from Fort Hood illustrates DoD's commitment to both biodiversity management and to minimizing constraints to the military mission, as captured in the INRMP (See Box below).

Box 5.1: Black-capped Vireo at Fort Hood and Fort Sill: INRMP captures commitments after delisting

By David Jones, Center for Environmental Management of Military Lands, Colorado State University

Just because a species is delisted doesn't necessarily mean it drops off the radar and ceases to be a focus of management. The black-capped vireo (*Vireo atricapilla*), federally listed in 1987 primarily because of nest-parasitism by brown-headed cowbirds (*Molothrus ater*) and habitat loss, was delisted by the FWS in 2018, after decades of effective management and recovery efforts. Fort Sill, Oklahoma, and Fort Hood, Texas, are two of the four largest publicly-managed areas containing the largest known black-capped vireo populations. Recovery efforts at these installations, in consultation with FWS and other partners, as well as extensive survey data spanning roughly 15 years contributed significantly to the species delisting by FWS.

According to the Final Rule published in the Federal Register (Volume 83 (No.73), May 16, 2018), "Under the authority of the Endangered Species Act of 1973 (Act), as amended, [the Service] removes the black-capped vireo (*Vireo atricapilla*, listed as *Vireo atricapillus*) from the Federal List of Endangered and Threatened Wildlife due to recovery. This determination is based on a thorough review of the best available scientific and commercial information, which indicates that the threats to this species have been reduced or managed to the point that the species has recovered and no longer meets the definition of endangered or threatened under the Act."

In its Species Status Assessment (SSA) report, which evaluates the species' needs, current conditions, and future conditions to support the proposed delisting rule, the FWS determined that inherent uncertainty exists in forecasting future threats and population status scenarios over a 50-year timeframe. To address this uncertainty and ensure the black-capped vireo continues to thrive, the SSA report and proposed rule noted the importance of continued management of known populations of the species. The FWS then obtained commitments from key federal, state, and private conservation partners, who are largely responsible for the recovery of the species, to continue to manage black-capped vireo populations on publicly managed lands and to promote management actions across the breeding range of the species. The FWS explicitly states that the Integrated Natural Resource Management Plans (INRMPs) for Fort Hood and Fort Sill will continue management actions that directly benefit black-capped vireos.

As noted in the final rule for delisting, “The Army continues to be an important partner in the conservation of the black-capped vireo. In particular, Fort Hood has provided a substantial amount of research and management toward the black-capped vireo, which has had a profoundly positive effect on the population. The Army’s commitment to the species has resulted in the largest known population under a single management authority at Fort Hood.”

Ecosystem management and biodiversity conservation

Key support for an ecosystem-management approach to natural resources management appeared in the DoD memorandum on implementing ecosystem management (1994), the subsequent DoDI 4715.3, Environmental Conservation Program (1996), and the Sikes Act Improvement Act in 1997 (SAIA). DoDI 4715.3 provides early guidance to the military services in implementing ecosystem management. The DoD Policy regarding ecosystem management and biodiversity conservation was derived largely from the recommendations of the “Keystone Center Policy Dialogue on a Department of Defense (DoD) Biodiversity Management Strategy” (Keystone Center 1996). The 1996 DoD Biodiversity Handbook (Leslie et al. 1996) and the NatureServe/TNC 2008 revision to the handbook (Benton et al. 2008) speak to and support that policy. The key elements of the 1996 DoD policy for ecosystem management include the following goals and principles:

Goal of ecosystem management

INRMPs are designed to ensure that military lands support present and future training and testing requirements while preserving, improving, and enhancing ecosystem integrity. Over the long term, that approach shall maintain and improve the sustainability and biological diversity of terrestrial and aquatic (including marine) ecosystems while supporting sustainable economies, human use, and the environment required for realistic military training operations.

Principles

- Maintain and improve the sustainability and native biodiversity of ecosystems.
- Administer with consideration of ecological units and timeframes.
- Support sustainable human activities.
- Develop a vision of ecosystem health.
- Develop priorities and reconcile conflicts.
- Develop coordinated approaches to work toward ecosystem health, e.g., involving the military operational community and other stakeholders in discussions.
- Rely on the best science and data available.
- Use benchmarks to monitor and evaluate outcomes.
- Use adaptive management.
- Implement ecosystem management through installation plans and programs.

An assessment of the implications of ecosystem management for threatened and endangered species conservation on Army lands (Trame and Tazik 1995) provides insights and identifies challenges for the transition between traditional species-centric approaches and ecosystem management: “The transition to ecosystem management will be challenged by several technical hurdles:

1. Ecosystem management will be more effective if threatened and endangered species management is done over large geographic areas, beyond the boundaries of the installations;

2. Ecosystem management will be more effective if managers have a thorough accounting of the native species, communities, and ecosystems that occur or would occur under natural conditions on their installations; it is a data-intensive approach;

3. Native elements need to be understood well enough that their relative roles in the ecosystem can be evaluated, threats to their existence can be identified, and "focal elements" can be identified for detailed planning efforts;

4. Management planning and activities should be shifted to a landscape scale, so that linkages and relationships among various regions of the installation can be recognized; and 5. A scientifically defensible, adaptive management monitoring framework will help capture advances in knowledge and improve management actions through a continuous feedback cycle.”

Trame and Tazik (1995) also predicted that “the overall management goals will shift away from income generation through extractive land use [read: timber management, livestock grazing, game management], towards conservation of biodiversity, ecosystem health, and biotic integrity.” They also describe a broadening of spatial and temporal scales associated with management as well as an expansion of expertise and incorporation of neighboring landowners to better manage TES using a regional approach. Incredibly, much of what they forecasted is becoming more commonplace on DoD lands.

Although ecosystem management is not specifically mentioned in the 1997 SAIA requiring the development of INRMPS, during the 2000s ecosystem management became more firmly embedded in natural resources management and INRMPS. According to DoD Instruction 4715.03 (March 2011, incorporating change 2 August 2018) DOD shall follow an ecosystem-based management approach to natural resources-related practices and decisions, using scientifically sound conservation procedures, techniques, and data, and each INRMP “shall incorporate the principles of ecosystem-based management.” Furthermore, DoD Instruction 4715.03 states that biodiversity conservation on DoD lands and waters should be followed whenever practicable to:

- Maintain or restore remaining native ecosystem types across their natural range of variation.
- Maintain or reestablish viable populations of native species on an installation, when practical.
- Maintain ecological processes, such as disturbance regimes, hydrological processes, and nutrient cycles, to the extent practicable.
- Manage and monitor resources over sufficiently long time periods to allow for adaptive management and assessment of changing ecosystem dynamics (i.e., incorporate a monitoring component to management plans).

As described above, the concepts, policies and guidance were being developed in the 1990s, and to some degree the profile of ecosystem management was raised in the initial INRMPs leading up to the 2001 deadline. However, execution of policies and guidance within installation programs and INRMPs continued to be incomplete.

A study examining the level of ecosystem management implemented across the military found that information and sufficient detail was lacking across the military services on ecosystem management, inventorying, monitoring, adaptive management and partnerships (Fittipaldi and Wuichet 2002). The study also concluded that some technical aspects of ecosystem management were poorly understood and could inhibit successful implementation of ecosystem management. Among study findings were:

- DoD ecosystem management policy is not reflected in Service-level policy and implementation guidance.
- Ecosystem management is incorrectly viewed as a separate activity requiring its own line item in natural resources budgets. Funding non-compliance-related ecosystem management projects is difficult and this hinders effective implementation.
- An adequate number of staff trained in ecosystem management principles is lacking. In general, natural resources staffs are small and, in many cases consist of only one natural resource manager; lack of staff can directly limit implementation.
- Low organizational status of natural resource managers impedes effective communication with others on the installation and in the region, and furthers reluctance among managers to partner with non-military entities in the region. Ineffective communication can also adversely impact implementation.

Fittipaldi and Wuichet (2002) proposed the following policy recommendations to ensure that ecosystem management is fully implemented and integrated within the day-to-day operations of all military departments:

- Promulgate and disseminate Service-level policy and guidance.
- Move closer to the goal of the DoD Instruction, where ecosystem management principles become not just special projects isolated from the rest of an installation's environmental program, but rather where they form the basis of decision making at the installation level. Require proposals for new or continuing special projects to demonstrate how they will accomplish or embody the ten principles in the Instruction, and require all INRMPs, as well as the projects proposed to implement them, to demonstrate how they will support the accomplishment of ecosystem management goals and objectives.
- Train staff and inform leaders at installations and Regional Environmental Offices on the principles of ecosystem management as described in the existing DoD Instruction and the recommended new Service-level policy and guidance.

Several years later, in the Legacy report "Best Practices for Integrated Natural Resources Management Plan (INRMP) Implementation," Gibb (2005a) believed there to be a good understanding of ecosystem management and that its application to day-to-day management had continued to improve as compared to the findings by Fittipaldi and Wuichet (2002). Refining and improving the ecosystem management aspects of the INRMP was reported by the natural resource managers to be the main focus for many of the INRMPs that required update or revision in the mid 2000s.

However, Gibb noted that there is still considerable room for improvement: "Although the process of ecosystem management is reasonably well understood and accepted, it is still not being fully practiced. The reasons for this are several and are not new—insufficient funds for INRMP projects and the oftentimes overwhelming emphasis on threatened and endangered species compliance management have been previously reported [by Fittipaldi and Wuichet 2002]…Commercial forestry should not be a focus of natural resources management on installations, [as] forestry goals may also compete with or be contrary to ecosystem health goals and objectives. There are four recognizable key areas to ecosystem management: 1) identifying and describing a vision for the installation (that is, a current and desired future condition or state); 2) identifying goals and objectives to move the installation in the direction of its vision or desired future condition; 3) having a monitoring program in place to measure progress to the goals and objectives; and 4) conducting adaptive management as needed to keep the installation on track, should monitoring indicate that progress is not being made as planned. Most installations included in the study have some or all of these elements in place; however, few have a comprehensive approach where there is a good linkage between the projects and activities conducted on the ground to progress towards the stated goals and objectives. Of these four elements, the area most lacking is monitoring, with few installations having a mechanism in place to determine progress."

A more recent study by Li and Male (2020) examined how DoD might expand or improve its conservation efforts on and around military lands over the coming decade. Among numerous recommendations about how improved landscape-scale planning could benefit national defense and conservation, they offered the following with respect to INRMPs: "Few people in the conservation community engage in the process for revising these plans, even when public comment is sought. More broadly, our observation is that the management plans have generally not served their goal of being integrated with FWS and state wildlife agency decisions. One reason for the poor engagement is that the wildlife agencies lack the resources to fully participate in plan development and revisions. Another reason is that some plans are drafted by contractors using a process that has not been designed to maximize engagement and buy-in from other federal agencies and stakeholders, although this process appears to enable efficient drafting of the plans."

They suggest several specific recommendations to improve the INRMP process:

- Evaluate the effectiveness of INRMP projects/activities: Researchers should study how the plans are developed and what effects they have had on conservation. Many outcomes of the INRMPs are anecdotal because no one has performed a comprehensive study of the documents and identified the best opportunities to improve the planning process.
- Increase funding to enable federal and state wildlife agencies to engage more effectively in plan development.

- Add capacity at the FWS to improve the planning process.

The Mission and the INRMP

Pursuant to the Sikes Act, mission sustainability is a primary driver of INRMPs. "It is DoD policy in accordance with…[DoD Instruction 4715.03, Environmental Conservation Program]… to implement and maintain natural resources conservation programs to ensure access to land, air, and water resources for realistic military training and testing while ensuring that the natural resources under the Secretary of Defense's stewardship and control are managed to support and be consistent with the military mission." (DoD Manual 4715.03).

This DoD Manual 4715.03 (2013) lists five guiding INRMP principles in support of mission sustainability:

(1) The goal of DoD environmental programs and policies is conserving the environment for mission sustainability.

(2) Each DoD Component will ensure that its INRMPs is, to the extent appropriate, applicable and consistent with the use of the installation, and enables the preparedness of the military services to provide for no net loss in the capability of military installation lands to support the military mission of the installation, pursuant to the Sikes Act.

(3) During the planning process, natural resources personnel consider appropriate management goals, objectives, and timelines for implementing actions to protect or enhance installation mission capabilities when determining INRMP resourcing priorities. Projects developed to support INRMP goals and objectives incorporate sustainable practices and take advantage of ecosystem management principles, where practicable.

(4) The DoD Component integrates mission requirements and priorities identified in the INRMP in other environmental programs and policies, where applicable, to help ensure these natural resources are maintained in the best ecological condition possible to fully support current and future mission requirements. The DoD Component annually evaluates INRMP effectiveness in preventing net loss, including accounting for instances where effective workarounds are implemented by natural resources personnel to ensure no net loss of training areas.

(5) There may be instances in which a net loss may be unavoidable to fulfill legal requirements other than the Sikes Act, such as complying with a biological opinion pursuant to the provisions of sections 1531-1544 of Reference (c) or protecting wetlands pursuant to section 1251 of Title 33, U.S.C., also known and referred to in this manual as "the Clean Water Act") (Reference (h)). To the extent practicable, the installation will identify the loss of mission capability in

these instances in its INRMP, and will include a discussion of measures taken to minimize the effects of any restrictions on training and testing.

Conflicts between mission and conservation present opportunities for creative solutions. As pressures increase for more frequent or intense training activity as well as new missions, natural resource managers must continually try to identify ways to mitigate the resulting impacts to natural resources. Recommendations by Tazik et al. (1990) were developed and promoted from the Integrated Training Area Management (ITAM) Program to help resource managers identify alternative actions to use in mitigating natural resource impacts (primarily soil and vegetation damage) caused by military training activities. In general, physical impacts to an installation's natural resources can be minimized by one of five management techniques: limit total use, redistribute use, modify kinds of uses, alter the behavior of use, and manipulate the natural resources for increased durability. Strategies and tools for implementing these techniques are shown in Figure 5.2.

Checklist for Minimizing Physical Impacts

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1. Limit Total Use on Installation

   a. Limit Total Number of Users
   b. Limit Total Days of Use
   c. Lease or Purchase Additional Land Near Installation
   d. Transfer a Portion of Total Activity to Other Installations
   e. Secure Suitable Land for a New Installation

2. Redistribute Use

   a. Seasonal Redistribution

      (1) Decrease Activity on Wet Soils
      (2) Decrease Activity on Unfrozen Soils
      (3) Reduce Time-Frame for Replacement of Vegetative Cover

   b. Spatial Redistribution

      (1) Decrease Use of Overutilized Areas
      - Establish a Closure Policy
      - Increase Restrictions
      - Limit Access
      - Decrease Desirability

      (2) Increase Use of Underutilized Areas
      - Establish a Required Use Policy
      - Decrease Restrictions
      - Improve Access
      - Increase Desirability

3. Modify Allowable Kinds of Uses

   a. Tracked/Wheeled Vehicle Use
   b. Cutting of Woody Plants for Camouflage
   c. Digging in Soil
   d. Training on Wet Soils
   e. Training During Period of High Fire Hazard
   f. Training on Unfrozen Soils

4. Alter Behavior Usage

   a. Teach to Protect
   b. Regulate to Protect

5. Manipulate Natural Resources to Improve Durability

   a. Burning
   b. Mechanical
   c. Biological
   d. Chemical

Figure 5.2. Checklist for minimizing physical impacts to an installation's natural resources.

Although the strategies described by Tazik et al. focus on soil and vegetation damage, many are relevant to minimize direct or indirect impacts to sensitive biological resources such as listed plants, animals and species at risk, and rare or critical habitat. These strategies and others are widely implemented by natural resource managers across DoD lands and by the Army's Integrated Training Area Management (ITAM) installation programs. Additional and related strategies are exemplified by a recent project that examined federally-listed and at-risk species, with a focus on Fort Carson in Colorado. The installation used a wide variety of strategies, including off-limits areas, limited-use areas, a maneuver damage program, wet weather deferment, training area rest and rotation, and geographic and seasonally-driven species restrictions (Grunau et al. 2017).

Another strategy is temporal (e.g., seasonal) closures or restrictions to protect species or habitat during periods that are ecologically important, for example, for nesting, brood-rearing, or hibernation. Examples of such strategies can be found at most installations: seasonal protections for bat hibernacula at Fort Leonard Wood, Missouri; spatial and temporal restrictions for sage grouse nesting and brood rearing areas within hundreds of thousands of acres of contiguous shrub-steppe habitat at Yakima Training Center, Washington; training rules and restrictions to protect habitat for ground squirrels, an important food source for raptors on the Morley Nelson Snake River Birds of Prey National Conservation Area, which overlaps with the NGB's Orchard Combat Training Center, Idaho; and training restrictions within areas managed with prescribed fire for open prairie habitats to favor military missions and the eastern regal fritillary butterfly at Fort Indiantown Gap, Pennsylvania.

When it comes to planning and conflict resolution between military training and sensitive resources, there are undoubtedly challenges where something has to give. However, there are often solutions to perceived conflicts that result in win-win scenarios for both conservation and training. Many installations develop an "environmental operations map" or similar that, in conjunction with range operations regulations and SOPs, helps display and disseminate geographic and temporal restrictions related to environmental sensitivities.

It is critical that natural resources staff, as well as others updating and revising INRMPs, have a good understanding of military missions and activities on the installation, and current or anticipated changes to training activities. Examples of specific types of training and mission information include:

- Vehicles and tactics
- Changes in weapons/weapon systems and live-fire activities (implications for soil disturbance, habitat degradation loss, wildland fire ignitions, noise, etc.)
- Off-road maneuvers, implications of vehicle types, missions and seasonality, mechanized vs. motorized

- Changes in number and size of units and major training events
- Changes in seasonality of training
- Other elements related to military training type and intensity such as land use loads, metrics, distribution of training across the landscape, and training footprint considerations and trends (Jones 2011).
- Contemporary Operating Environment (COE) facilities and use—e.g., military operations in urban terrain (MOUT)—can contribute to uneven distribution, and patchy disturbance.
- Shifts in equipment due to Theatre of War (TOW) considerations, such as the heavy to medium vehicle conversions starting in the mid-2000s. This was reflective of a changing focus from temperate Eurasian environments characteristic of post-Cold War settings to more arid Middle Eastern environments and an increase in COE associated with the Global War on Terror. The missions, distribution of use (e.g., less off-road/free maneuver, training impact severity (e.g., wet vs. dry soils) and ecological impacts may shift with these changes in global TOW drivers over time.

INRMP structure and content

The 2006 OSD Memo entitled Integrated Natural Resources Management Plan Template provided structure and content guidance for all new INRMPs as well as those that undergo major revisions. The intent of the template was to ensure that each Military Service delivered consistent information in a similar format to expedite review by the FWS and State fish and wildlife/natural resources agencies. It was not meant to be all-inclusive, as DoD Components or their installations may add additional sections that are appropriate for their specific situations. The outline included and annotated in the memo (shown below) continues to be used as a touchstone by installations, although actual organization and content may vary. Additional INRMP content guidance is provided in DoD Manual 4715.03, Integrated Natural Resources Management Plan (INRMP) Implementation Manual (2013, Incorporating Change 2, August 2018).

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Executive Summary

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   d) Funding – briefly describe the funding process

Appendices - at a minimum, the following should be included:

1. List of Acronyms
2. Detailed management prescriptions that drive the projects, with cost estimates, funding classes and projected timeframe
3. List of Projects
4. Survey results
5. Research requirements/needs
6. Migratory Bird Management
7. INRMP Benefits for Endangered Species – identifies all management and conservation efforts for a listed species that could inform determination to not designate critical habitat on an installation
8. Critical Habitat Issues – how might critical habitat designation impact training and the mission?
9. Incorporate important SOPs, BMPs, and other guidance into the INRMP by reference or in an Appendix – e.g., use of native species in revegetation projects,

SOPs for land/soil disturbance projects, SOPs for biocontrol/biosecurity (e.g., sanitation, inspection, and coordination, etc.) to minimize spread on nonnative species on/off the installation or among different parts of the installation, and training regulations/SOPs related to fire restrictions, maneuver on wet soils, off-limits areas due to conservation sensitivities, etc.

For Army installations, Integrated Training Area Management program elements, objectives and activities are also embedded in the INRMP. The sections and list of topics covered by the outline and other guidance are extensive, but not exhaustive. USAEC (2009) developed additional recommendations for INRMP content and organization.

The key is to organize and convey all information related to goals, strategies, objectives, activities/projects, compliance, military mission context, partnerships, etc. in a comprehensive yet cohesive and digestible form, presented within the framework of ecosystem management and employing iterative adaptive management practices. If the INRMP is not current (or perceived to be out of date), easy to read and use, then it's less likely to be referenced and applied on a regular basis.

INRMP development

The process of developing, as well as reviewing and revising an INRMP (more on the latter in the INRMP Review, Revisions and Updates section below) is a significant undertaking. The task requires a dedicated interdisciplinary team well-versed in military land management and with environmental and natural resources subject matter expertise, as well as a project leader who may be a subject matter expert as well. Types of expertise and important roles include:

- Project lead
- National Environmental Policy Act (NEPA)
- Stakeholders (internal, external interest groups/stakeholders)
- Natural resources experts/staff (e.g., plant biologist/ecologist, wildlife and fisheries biologist, TES specialist, watershed/soils specialist, forester, rangeland specialist/ecologist, agronomist, etc.)
- GIS specialist
- Master planning specialist
- Range and Training Operations staff and personnel
- Conservation law enforcement

- Integrated Training Area Management (ITAM)
- Wildland fire and safety personnel
- Outdoor recreation
- Hunting/fishing
- Conservation law enforcement

The INRMP team may include a combination of in-house installation staff, state and federal expertise, academic institutions, the installation training community, cooperators and contractor support, community partners and local NGOs/stakeholders. For installations with small natural resources staff, one or several people may wear many hats. The role of federal and state agencies in developing INRMPs is discussed further in the section entitled INRMP Review, Revisions and Updates below.

Plan implementation

After developing the INRMP, the DoD Components and installations implement the INRMPs through the following process[27]:

1. Actively requesting and using funds for natural resources management projects, activities and other requirements in support of goals, and objectives identified in the INRMP.
2. Ensuring enough professionally trained natural resource management personnel are available to perform the tasks required by the INRMP.
3. Inviting annual feedback from the appropriate FWS and State fish and wildlife agency offices on the effectiveness of the INRMP (see INRMP Review, Revisions and Updates section in this chapter).
4. Documenting specific INRMP action accomplishments undertaken each year.
5. Evaluating the effectiveness of past and current management activities and adapting those activities [or associated goals and objectives] as needed.

The Sikes Act requires that professionally trained natural resource managers be employed at all installations requiring an INRMP. The Sikes Act further stipulates that if qualified individuals cannot be found within the military service to implement the INRMP, then priority should be given to an appropriate federal or state wildlife

[27] DoD Manual 4715.03, Integrated Natural Resources Management Plan (INRMP) Implementation Manual, November 2013, Incorporating Change 2 August 2018.

management agency to execute it. However, this policy has not been formally adopted by all the military services. Even where it has, such as in the Air Force, it is sometimes not enforced. The result is that some natural resources positions are filled with individuals lacking formal natural resources backgrounds or training.

Typically, individuals with civil engineering backgrounds are selected for these positions or, in some cases, individuals with no formal professional natural resources training whatsoever (Ripley 2008).

Installation staff execute or oversee implementation of the INRMP. DoD (federal) and state military department/NGB staff have key roles with respect to representing their agency/installation and authorizing expenditures. Interagency staffing is sometimes provided using the Intergovernmental Personnel Act. Ongoing or periodic communication and coordination with federal and state agencies is expected, especially for sensitive resources. It is also common that non-federal entities, i.e., cooperators (partners through cooperative agreements) and contractors (partners through contracts), provide on-site support to INRMP activities. See Chapter 6, (Partnerships) for a discussion of using universities to support installation conservation, and Chapter 7 (on Funding) for a discussion of contracts vs. cooperative agreements.

Knowledge of the installation and resource issues (adapted from CEMML 2006)

Installation-specific knowledge by natural resources staff is critical to effective INRMP implementation. To be able to communicate with trainers, Range Operations, military personnel from the lowest to highest levels, installation Facilities/Public Works offices, and natural resources personnel, it is essential to "know the installation." This is especially true for staff who are new to an installation, as it allows them to communicate well with others and better understand the military and natural resource context. Types of information related to knowing the installation mostly fall into the following categories: 1) training units, missions, activities and impacts; 2) installation infrastructure, ranges and training areas, access and coordination; 3) natural resources components, patterns and dynamics.

This knowledge can be gained through first-hand experience (e.g., learning the road system by driving it), academic study (e.g., reading The Range and Training Land Program (RTLP) and INRMP) and by learning through interaction with others (e.g., meeting with and getting to know long-time staffers such as the range officer, forester, rangeland manager, etc.). Time in the field spent observing your surroundings and making notes is crucial to developing site-specific knowledge. ITAM staff are also a valuable source of information about training activities, locations and impacts. More details on "knowing the mission" are in the Mission and the INRMP section above.

INRMPS and critical habitat designation

Critical habitat consists of specific areas within the geographical area occupied by the species at the time it is listed on which are found those physical or biological features that are essential to the conservation of the species, and which may require special management considerations and protection. Critical habitat also includes specific areas outside the geographical area occupied by the species at the time it is listed that are essential for the conservation of the species.

As part of the 2004 Endangered Species Act (ESA) amendment, section 4(a)(3) exempted the DoD from critical habitat designations so long as an integrated natural resources management plan prepared under section 101 of the Sikes Act (16 U.S.C. 670a) and acceptable to the Secretary of the Interior is in place. Section 4(b)(2) of the 2004 amendment allows the Secretary of the Interior to make critical habitat exclusions for economic or national security considerations. The DoD subsequently prepared specific guidance regarding the ESA amendment. The following, excerpted from DoD Manual 4715.03, Integrated Natural Resources Management Plan (INRMP) Implementation Manual (November 25, 2013, incorporating change 2 from 2018), provides detailed DoD guidance:

1) On the topic of critical habitat exclusion and special management criteria:
   a) ESA
      (1) Critical Habitat Designation Restrictions. Pursuant to section 4(a)(3)(B)(i) of the ESA, the Secretaries of the Departments of Interior and Commerce are prohibited from designating as critical habitat any lands or other geographical areas owned or controlled by the DoD, or designated for its use, that are subject to an INRMP prepared pursuant to section 670a of the Sikes Act. This restriction applies if either Secretary determines in writing that a given INRMP provides a benefit to the species for which critical habitat is proposed for designation pursuant to section 318 of Public Law 108-136 (Reference (l)).

      (2) Threatened and Endangered Species and Critical Habitat. Pursuant to section 7 of the ESA, the DoD consults with the FWS, and NOAA Fisheries when threatened or endangered species or designated critical habitats are in question, to ensure no DoD action will likely jeopardize the continued existence of listed species, or destroy or adversely modify designated critical habitats. An Incidental Take Statement acquired in accordance with section 7(b)(4) of the ESA is necessary for DoD action proponents to be exempt from the take prohibitions described in section 9 of the ESA.

b) FWS Special Management Criteria. The FWS uses three criteria to determine if an INRMP provides adequate special management or protection to eliminate the need for critical habitat designation:

   i) The INRMP provides a conservation benefit to the listed species. The cumulative benefits of the management activities identified in the INRMP for its duration maintains or provides for an increase in a species' population or the enhancement or restoration of its habitat within the area included in the INRMP (i.e., those areas essential to the conservation of the species). A conservation benefit may result from reducing habitat fragmentation, maintaining or increasing populations, insuring against catastrophic events, enhancing and restoring habitats, buffering protected areas, or testing and implementing new conservation strategies.

   ii) The INRMP provides certainty that relevant agreed-on actions will be implemented. Persons implementing the INRMP can accomplish its goals and objectives, have adequate funding to implement agreed upon activities, have implementation authority, and have obtained all the necessary authorizations or approvals. The INRMP includes an implementation schedule, including completion dates, for the conservation effort.

   iii) The INRMP provides certainty that the conservation effort will be effective. FWS considers these criteria when determining the effectiveness of the conservation effort:

      (a) Biological goals, which are broad guiding principles for the program, and objectives, which are measurable targets for achieving the goals

      (b) Quantifiable, scientifically valid parameters that demonstrate achieving objectives and standards measuring progress.

      (c) Provisions for monitoring and, where appropriate, adaptive management.

      (d) Provisions for reporting progress on implementation based on compliance with the implementation schedule and effectiveness based on evaluation of quantifiable parameters of the conservation effort.

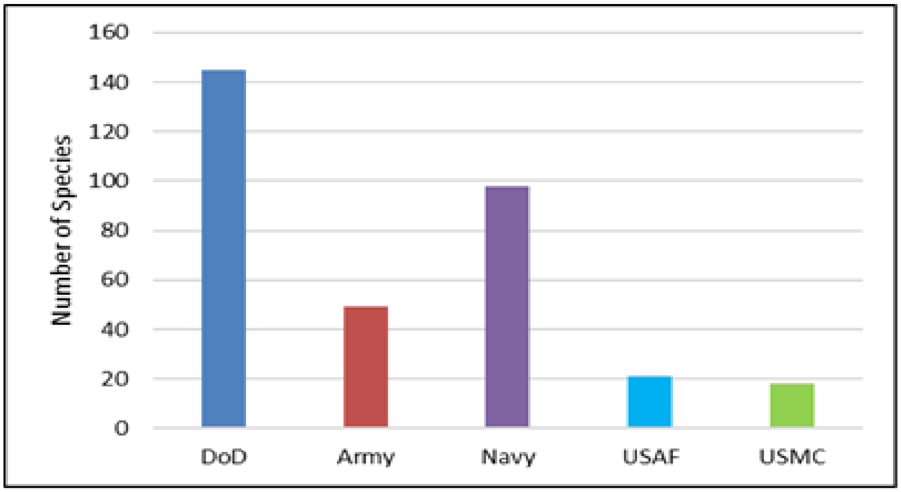
      (e) A period of time sufficient to implement the actions and achieve the benefits of its goals and objectives.

c) Exclusion. Pursuant to section 4(b)(2) of the ESA, the Secretary of the Interior may exclude a military installation or portion of an installation from critical habitat if, after considering the economic impact and the impact on national security, the Secretary determines that the benefits of exclusion outweigh the benefits of inclusion. An installation provides the necessary and relevant information explaining the national security implications of critical habitat designation on the military installation.

2) On the topic of implementation to avoid critical habitat: To take advantage of the ESA 4(a)(3)(B)(i) exemption and avoid FWS or NOAA Fisheries designation of critical habitat on DoD installations, each installation implements its INRMP by executing appropriate projects and activities in accordance with specific timeframes identified in the INRMP. The DoD Components prioritize projects with the assistance from the FWS, appropriate State fish and wildlife agencies, and NOAA Fisheries if applicable. The DoD Components may provide this information after review and validation of the priorities and estimated costs of the requirements.

Army guidance is presented in the memo entitled “Army Guidance on Endangered Species Act (ESA) Critical Habitat (CH) Designations and Consultations” (December 2005). Additional guidance may exist for other services.

Collectively, the exemptions and exclusions under the 2004 ESA amendment are considered critical habitat “avoidance”. Among the military services, the Navy has the highest number of species habitat exemptions and exclusions (Figure 5.3). Of the roughly 400 critical habitat actions between DoD and ESA regulatory agencies from FY2004 through FY2017, 62% resulted in exemptions, 31% resulted in exclusions, and 7% resulted in critical habitat being designated on an installation.



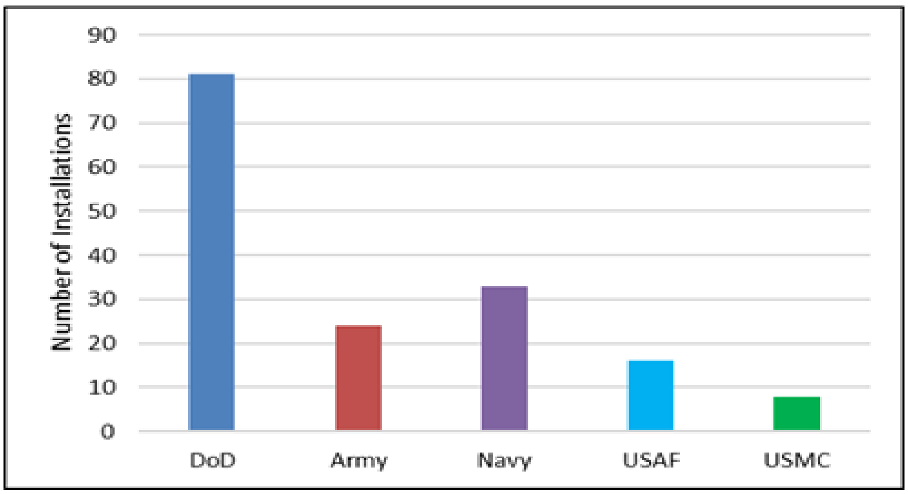


Figure 5.3. Number of species (top) and number of installations (bottom), DoD-wide, which have had critical habitat exemption or exclusion, FY2004 through FY2017. Due to some overlap in species among the military services, the sum of all is greater than the DoD total. (Source: DoD Natural Resources Program, OASD (Sustainment)/ODASD(Environment), February 2021).

Recent critical habitat exemptions that have been made possible by INRMP commitments (section 4(a)(3)) include the threatened piping plover (Charadrius melodus) at Marine Corps Base Camp Lejeune in 2015, the endangered Florida brickell-bush (Brickellia mosieri) at Patrick Air Force Base in 2015, various distinct population segments of the endangered Atlantic sturgeon (Acipenser oxyrinchus oxyrinchus) at West Point Military Academy and several east coast Navy facilities, and the endangered Taylor's checkerspot (Euphydryas editha taylori) at Joint Base Lewis-McChord in 2013.

Several years following the ESA amendment, May and Porier (2006) examined the issue with an article in the Air Force Law Review. Overall, they concluded that the INRMP is an acceptable substitute for critical habitat designation, as long as it is thoroughly prepared and adequately funded. They emphasized attention to procedural and substantive INRMP elements to ensure that ESA requirements are fully supported and that the INRMP embraces a broad perspective, true to the principles of ecosystem management, which extends beyond the installation boundaries. They identified the following perceived “weak spots” in using INRMPS in lieu of critical habitat designation and proposed remedies to strengthen INRMPs (May and Porier 2006).

- Concern: A military installation could have its INRMP qualify as adequate special management or protection if the FWS determined that the INRMP provided a “conservation benefit to the species” and met two additional criteria listed above. However, the FWS or the legislation does not specifically define that language. Remedy: the FWS should promulgate a standard definition for “conservation benefit to the species.”

- Concern: Any INRMP is only as good as its funding. Therefore, its substitution for critical habitat designation should be dependent on the underlying funding. Proof of adequate funding was previously required to get the designation substitution. Not all actions and projects covered in an INRMP fall into the “must fund” category, which may lead to important portions of INRMPs never being implemented due to lack of funds. Remedy: The DoD would be prudent to ensure that INRMPs are adequately funded every year. Without a definition of “benefit to the species” in place, it is possible that an INRMP could be approved by the FWS and then not be adequately funded in subsequent fiscal years, reducing the INRMP’s effectiveness.

- Concern: “Reasonable and prudent” measures included in biological opinions issued by the FWS can only impose minor changes on the DoD action, but must be complied with by the DoD. Remedy: Because the reasonable and prudent measures are a result of consultation with the FWS regarding threatened or endangered species and habitat, any conditions placed upon an installation as a result of reasonable and prudent measures should be included in the underlying INRMP.

- Concern: FWS species recovery plans must contain a description of site-specific management actions necessary to achieve the goal of the plan—objective, measurable criteria that, when met, warrant the species being de-listed—and time estimates for obtaining the plan’s goal. Most significantly for INRMP considerations, any new or revised recovery plan must provide public notice and opportunity for comment. Remedy: A successful INRMP should encompass recovery plans for any endangered or threatened species on the installation.

- Concern: DoD, through consultation with the FWS, is required by the ESA to be proactive in furthering the purposes of the ESA by planning for and carrying out conservation programs for listed species. Cooperatively developed conservation agreements, management plans, and recovery plans developed for listed species are often implemented and funded through partnerships and memoranda of understanding (MOUs) with the FWS. Remedy: MOUs that have been implemented for a DoD installation should be included within the INRMP.

- Concern: Adjacent private lands may not be addressed in the INRMP. Remedy: A variety of programs and arrangements for private landowners (e.g., habitat conservation plans, safe harbor agreements, candidate conservation agreements to help them manage endangered species on their own land) should be considered in a successful INRMP.

Installation hunting and fishing activities[28]

The Sikes Act includes specific provisions for the hunting and fishing program. Under the Sikes Act, installations are given the authority to issue hunting and fishing permits to individuals and to collect permit fees. Installations are to retain the permit fees and use the revenue for the protection, conservation, and management of fish and wildlife in accordance with the INRMP. The act also stipulates that the sale of forest products and the leasing of lands for agriculture and grazing must be compatible with the installation's INRMP.

The Sikes Act Improvement Act of 1997 (SAIA) also reinforces the autonomy given to the installation commanders by providing the authority to "collect, spend, administer, and account for fees" for the hunting and fishing programs. The law requires that the fees be used to protect, conserve, and manage fish and wildlife and that the INRMP prescribe the specific use of fees. In addition, the SAIA maintains the requirement that land or forest products may not be sold or leased unless the sale or leasing is compatible with the INRMP.

Recent advances in software apps (e.g., iSportsman) and use of mobile phones to manage hunting and fishing permits and use/access of hunting and fishing areas has greatly enhanced the capacity of installation staff to manage hunters and anglers. DoD and the military services have in some cases subsidized the cost of software to support these improved efficiencies.

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[28] Aec.army.mil

Integrating state wildlife action plan priorities

State Wildlife Action Plans (SWAPs) are developed by U.S. states and territories to help conserve wildlife and habitat before they come under consideration for listing by the FWS. In 2005, all 50 States and five U.S. Territories developed a SWAP and submitted them for approval to the FWS as a condition for receiving funding through the State and Tribal Wildlife Grants program. Each plan includes the identification of Species of Greatest Conservation Need (SGCN) for that state, an evaluation of threats and identification of action steps to recover and conserve imperiled wildlife. Required revisions (every 10 years or less) to SWAPs occurred in 2015 with all 50 States and five U.S. territories submitting their current plans for review and compilation into a national list.

The SGCN are identified and evaluated using a variety of information sources and criteria, including current state and federal status, NatureServe Network Programs and other wildlife occurrence databases, data from other planning efforts and assessments (including data from DoD and installations), and input from agency biologists, academics, and other scientific experts. States identify SGCN based on a variety of criteria: if a species had low populations, had already been formally identified as a conservation priority, or showed other signs of imminent decline, it was flagged for attention. Some states use a tiered approach, prioritizing their state's wildlife of concern in two or more levels of concern or priority. Because each state uses a different approach, the wildlife identified as SGCN vary significantly. For example, the South Carolina action plan identifies more than 1,200 species in need of conservation, while the North Dakota wildlife action plan identifies 100 (Oberbilling, undated). In partnership with the Association of Fish and Wildlife Agencies, the U.S. Geological Survey developed a process that allows the SGCN from all the state plans to be compiled and accessible via the Species Conservation Analysis Tool[29].

Under a Legacy Program grant, Klopfer and Kane (2017) developed a "downscaling" process for integrating SWAP SGCNs into INRMPs to minimize federal listings that could impact military training. This approach aims to reduce the number of SGCN at each step of the downscaling process described below (Klopfer and Kane 2017):

1. Determine the installation landscape—e.g., ecological or administrative boundaries, existing off-installation partnerships, or shared boundaries and conservation goals with neighbors.

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[29] https://www1.usgs.gov/csas/swap/

2. Identify Wildlife Action Plan SGCN and associated information, e.g., data, threats and management actions.
3. Identify species within the installation landscape.
4. Identify SWAP priority SGCN on the installation.
5. Determine which priority SGCN are installation priorities.
6. Identify associated threats and conservation actions.
7. Conservation opportunities, existing efforts, and potential mission conflicts.

Klopfer and Kane (2017) recommend focusing on the integration of specific SGCN especially where:

- The installation comprises a significant portion of the species' range.
- Installation activities provide unique opportunities.
- Economies of scale with habitat conservation are achievable.
- The installation is critical for continued presence within the greater landscape.

DoD species at risk

Species at risk (SAR) considerations should be included in the INRMP. According to DoDI 4715.03: "To the extent practicable, all DoD Components shall establish policy and procedures for the management of species at risk (SAR) to prioritize proactive management of those species that, if listed, could adversely impact military readiness. Program objectives shall focus on efforts that have the greatest potential to prevent the listing of SAR (e.g., habitat conservation, planning level surveys, monitoring). Protecting these species is critical; therefore, the installation INRMP should consider funding for SAR protection a high priority."

A comprehensive analysis of SAR applying these criteria on DoD lands was last completed by NatureServe (2015) (see discussion of that analysis in Chapter 1). That analysis defined SAR as native, regularly occurring species in the United States that are not federally listed under the U.S. Endangered Species Act, but are either:

- Candidates for listing under the U.S. Endangered Species Act, or
- Proposed for listing under the U.S. Endangered Species Act, or
- Critically imperiled (rounded global rank of G1 or T1), or
- Imperiled (rounded global rank of G2 or T2) plants and animals, according to the NatureServe conservation status rank criteria, or

- Vulnerable birds with a rounded global rank of G3 according to the NatureServe conservation status rank criteria or an IUCN status of critically endangered, endangered, vulnerable, or near threatened[30].

The results were remarkable, with extremely high densities of SAR as well as threatened and endangered species occurring on military lands compared to other Federal land management agencies. The results can be even more extraordinary when detailed installation occurrence data are incorporated into the analysis (See box below). Plants and animals identified as DoD species at risk could also be integrated within the Klopfer and Kane (2017) framework, specifically by substituting SAR for SGCN in steps 2-7 of the SWAP integration process shown above.

Box 5.2: The Army is managing species at risk on the Island of Hawai'i

By Dave Jones and Lena Schnell, Center for Environmental Management of Military Lands, Colorado State University (CEMML/CSU). Adapted from an article published in the Fall 2020 edition of "Natural Selections," the newsletter of the DoD Natural Resources Program[31].

Island ecosystems harbor many rare and endemic species that are vulnerable to invasion and new disturbances. U.S. Army Garrison, Pohakuloa Training Area (PTA) personnel, located in one of the most biodiverse areas in the world, are persistently working to prevent additional species listings under the Endangered Species Act (ESA). Currently, PTA manages 20 ESA-listed plants and six ESA-listed animals, as well as many additional species at-risk (SAR) to prevent their future ESA listings. Avoiding species listings can increase installation and mission resilience. Specific threats to listed species and SAR at PTA include habitat loss and degradation, predation by non-native animals (e.g., feral ungulates, rats, cats, mongoose), wildland fire, extreme weather events (e.g., drought), land development and military activities, and invasive species. A changing climate will likely exacerbate invasive plant competition, wildland fire risk, and drought stress.

In 2019, CEMML conducted an in-depth analysis to identify all SAR at PTA. Specifically, CEMML gathered information through literature reviews, state and federal data, NatureServe data, and installation data to identify species meeting

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30 For an explanation of NatureServe status ranks, see https://www.natureserve.org/conservation-tools/conservation-status-assessment

31 https://www.denix.osd.mil/nr/

DoD's SAR criteria. The baseline data helped to determine which SAR have a higher priority for management and monitoring. Additionally, some SAR may require more active management practices than others. Identifying these specific needs on installations can help maintain the overall biodiversity and health of the ecosystem.

The analysis, the first step toward developing comprehensive SAR planning and management, identified 26 plant SAR and 24 animal SAR observed on PTA. The 50 total SAR are nearly four times the previous 13 SAR on PTA estimated by NatureServe (2015). This discrepancy is likely due to a combination of incomplete data for the 2015 analysis; changes in species occurrences, federal status, taxonomy, and conservation status ranks; and varying levels of access to installation data. Keeping data up to date is a critical component to species management on any installation. These results identified SAR that were not previously present or recognized, and will help guide management actions for all SAR on PTA, as well as support Recovery and Sustainment Partnership (RASP) Initiative efforts between DoD and the Department of the Interior.

Managing for climate change through INRMPs

Guidance on how to consider climate change impacts, and strategies for how to address them through natural resource management, is available through multiple military instructions and manuals. One of the earlier Literature Cited to climate change within the context of DoD natural resources management is in DoD Instruction 4715.3, Environmental Conservation Program (1996). Among the numerous principles and guidelines for ecosystem management is the following: "Ecosystem management requires consideration of the effects of installation programs and actions at spatial and temporal ecological scales that are relevant to natural processes… Consideration of sustainability under long-term environmental threats, such as climate change, is also important." The Instruction requires all DoD components to assess the potential impacts of climate change to natural resources on DoD installations and to develop and implement adaptive management strategies.

DoD Manual 4715.03, Integrated Natural Resources Management Plan (INRMP) Implementation Manual (2013) contains guidance on climate change planning (see Enclosure 8: Planning for Climate Change Impacts to Natural Resources). The manual notes that "ecosystem effects of climate change will likely be incremental and challenging to distinguish and address." For this reason, planning and managing for climate change must rely on an "adaptive process of developing, validating, and improving forecast models." It directs natural resources personnel to use a wide variety of information when updating an INRMP to incorporate climate change considerations, to include:

- Historical regional trends and projections of future climate or sea level rise relevant to the region.

- Information developed for other purposes (e.g., facilities risk assessments) that natural resources personnel can use to assess climate change impacts or adaptation strategies.
- A discussion of sustainability in the context of climate change in the management strategies section. This discussion should support, at a minimum, the development and updating of vulnerability assessments. These must be identified in the INRMP and the implementation table to ensure allocation of funding.
- Information from regional collaboration to develop vulnerability assessments and adaptation strategies.
- Collaboration with DoD mission leads for comprehensive incorporation of training and test vulnerabilities related to climate change.

The manual also provides guidance on conducting vulnerability assessments and exploring how rare species vulnerabilities may impact installation missions; adding climate change to INRMP threats analysis; updating best management practices in response to potential climate change risks to unique landscapes, ecosystems, and habitats; and directing natural resources personnel to collaborate with natural resources agencies and the public to proactively identify the likely effects of climate change, to adapt, meet compliance requirements, and manage resources effectively.

The military services have developed supplemental guidance in response to DoD and Service policy and guidance. For example, Air Force Instruction 32-7064, Integrated Natural Resources Management (November 2014), identifies requirements to manage natural resources on Air Force installations in accordance with applicable federal, state, and local laws and regulations. Paragraph 3.8.3 speaks specifically to climate change in the context of installation INRMPs: "Changing climate conditions may significantly affect native ecosystems and require the Air Force to adjust natural resources management strategies to support military mission requirements and address the needs of sensitive species. INRMP goals and objectives for ecosystem management and biodiversity conservation must consider projected climate change impacts and favor an adaptive ecosystem-based management approach that will enhance the resiliency of the ecosystem to adapt to changes in climate. The INRMP will assess climate change risks, vulnerabilities, and adaptation strategies using authoritative, region-specific climate science, climate projections, and existing tools. The INRMP should list, or include by reference, installation-specific climate data and region-specific climate projections from the most current quadrennial National Climate Assessment Report, and include other pertinent Federal climate science documents as appropriate." Similar guidance in the form of instructions and manuals also exists for the Navy, Marine Corps and Army.

Building on sustainability issues raised in DoD's annual Climate Change Adaptation Roadmap, and in response to requirements in the National Defense Authorization Act of 2018, DoD prepared its Report on Effects of a Changing Climate to the Department of Defense[32] in 2019. The report, focused on results from 79 mission priority installations, provides an assessment of the significant current and potential vulnerabilities to installation lands and infrastructure from climate-related events over the next 20 years. The list of climate-related events was limited to five climate-change related events: recurrent flooding, drought, desertification, wildfires, and thawing permafrost (Table 5.1). Some impacts are closely related or intensify the effects of each other (e.g., drought, desertification, wildfire), whereas others are somewhat related (e.g., coastal flooding driven by changing sea level can impact river conveyance, compounding riverine flood levels for tidally influenced rivers). Taken together, however, these impacts help describe the overall vulnerabilities to DoD installations from changing future conditions. Results indicate that recurrent flooding, drought, and wildfires are the primary concerns at the 79 installations included in the analysis. The analysis did not address biological impacts or vulnerabilities associated with climate change.

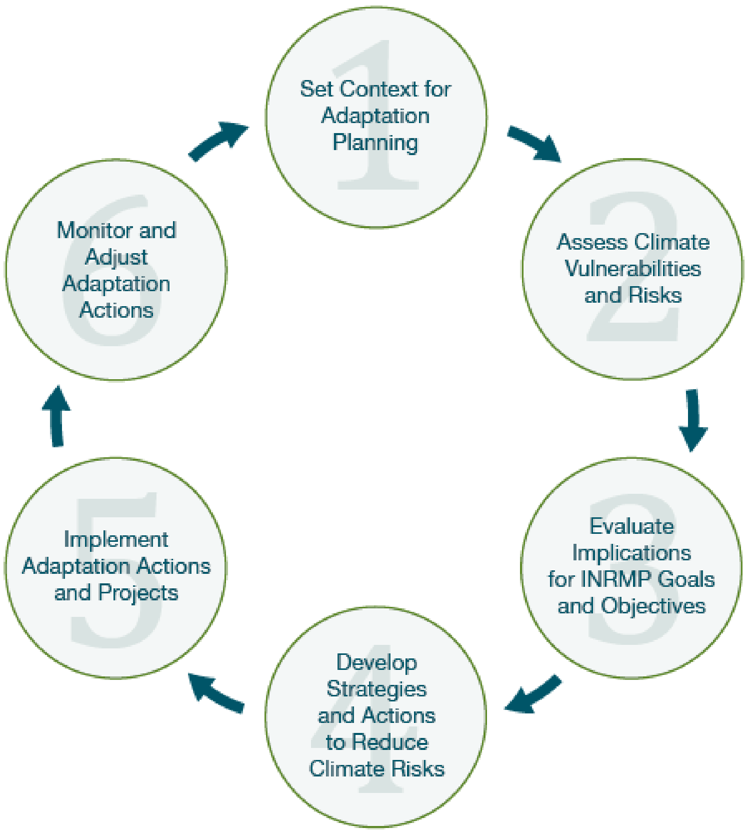
Table 5.1 Summary of current and future (20 years) vulnerabilities to military installations (Office of the Under Secretary of Defense for Acquisition and Sustainment 2019).

		Recurrent Flooding		*Drought*		*Desertification*		*Wildfires*		*Thawing Permafrost*	
Service	# Installations	Current	Potential	Current	Potential	Current	Potential	Current	Potential	Current	Potential
Air Force	36	20	25	20	22	4	4	32	32	-	-
Army	21	15	17	5	5	2	2	4	4	1	1
Navy	18	16	16	18	18	-	-	-	7	-	-
DLA	2	2	2	-	2	-	-	-	-	-	-
DFAS	1	-	-	-	1	-	-	-	-	-	-
WHS	1	-	-	-	-	-	-	-	-	-	-
Totals	79	53	60	43	48	6	6	36	43	1	1

There was enormous progress and momentum between roughly 2005 and 2015 to integrate climate change into INRMPs. However, as of 2015 there was still little to no specific consideration of installation-specific climate change exposure, species and habitat vulnerability, and adaptation planning/implementation within INRMPS. The typical INRMP of the era might have contained a single paragraph speaking to DoD's recognition of the issue and its commitment to integrating it as a potential threat/stressor, or perhaps a brief discussion of climate change mitigation. However,

[32] Prepared by the Office of the Under Secretary of Defense for Acquisition and Sustainment.

the capability of installations with respect to expertise and staffing capacity was extremely limited. This continues to largely be the case and is also common among other federal and state natural resource management agencies. To help remedy the situation and provide a more specific and applied framework for installation natural resource managers, DoD funded the development of a technical guide: Climate Adaptation for DoD Natural Resource Managers: A Guide to Incorporating Climate Change Considerations into Integrated Natural Resources Management Plans (Stein et al. 2019).[33] The guide introduces installation managers to overarching adaptation concepts and principles, and is structured around a generalized, yet flexible, INRMP adaptation planning process consisting of six steps:



The guide consists of two major sections. Part I includes an overview of climate risks to military installations and mission requirements; an introduction to adaptation; a brief primer on climate science; a review of options for incorporating climate concerns into INRMPs; and a summary of climate and adaptation considerations for individual INRMP program elements. Part II offers a step-by-step method for carrying out the INRMP adaptation planning process. A series of appendices provide

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33 https://www.denix.osd.mil/nr/dodadaptationguide/

sources of adaptation-related information and expertise and a set of detailed worksheets that support installation-level application of the six-step INRMP adaptation planning process (see box below). Training in applying the concepts has been provided by the guide author and others in workshop settings. This has begun to build capacity for INRMP integration among DoD and installation staffs, contractors, and cooperators.

Box 5.3: Practicing climate adaptation and enhancing installation resilience: Integrating climate change considerations in the INRMP

By Dr. Bruce Stein, National Wildlife Federation. Adapted from an article published in the Fall 2020 edition of “Natural Selections,” the newsletter of the DoD Natural Resources Program[34].

DoD lands and waters harbor an extraordinary array of wild species and natural ecosystems, essential for a high-quality training and testing environment. Understanding climate-related vulnerabilities to these natural resources, and designing strategies to reduce resulting risks, is critical to maintaining mission requirements and supporting installation resilience. In 2019, the DoD released “Climate Adaptation for DoD Natural Resource Managers,” a guide designed to help installations incorporate climate concerns into INRMPs. The guide is a tool for implementing policy in DoD Manual 4715.03, Integrated Natural Resources Management Plan Implementation Manual, which calls for installations to address potential climate impacts when revising or updating their INRMPs.

The guide introduces the emerging discipline of climate adaptation, reviews the impacts a changing climate may have on various INRMP program elements, and provides options for incorporating climate considerations within the structure of the INRMP document itself. The guide also offers a structured planning process for evaluating climate-related risks and drafting strategies and actions to address impacts that could compromise installation functions and readiness.

Natural resources personnel can use the guide at several levels, depending on where an installation is in both their INRMP planning cycle and their efforts to address climate concerns. The guide outlines the basic process for adaptation planning, including climate vulnerability assessments and design of strategies to reduce associated risks. The guide lays out a six-step INRMP adaptation planning framework designed to help installation managers understand how a changing climate may affect their resources and management objectives; develop and

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[34] https://www.denix.osd.mil/nr/

document potential adaptation responses; and ultimately evaluate, select, and implement climate-informed natural resources projects.

This step-by-step cycle is supported by a series of detailed worksheets that can help managers systematically work through the adaptation process. By providing ways to elicit and record key information and decisions, the worksheets also offer tools for revisiting and updating adaptation planning over time—the essence of “iterative risk management.” Importantly, the six-step planning framework and associated worksheets are intended as an aid, not a mandate.

The adaptation guide offers different options for how installations can incorporate climate considerations into the INRMP process and document. For those just beginning to think about climate impacts on their installation, the guide provides an overview of climate science, an introduction to adaptation and resilience principles, and a selection of relevant literature and other informational resources. Those undertaking a complete INRMP revision can address a changing climate throughout the INRMP using a “full-integration” approach. This approach helps to ensure that climate concerns are integrated across the full range of resources and program activities. Those who have just started to consider climatic concerns, or who are in between full revision cycles, can address a changing climate in an INRMP appendix using an “appendix-only” approach.

The guide and its associated resources (i.e., worksheets, fact sheets) are already helping to inform adaptation planning and INRMP revisions at installations nationwide. In one example, managers at the Army’s PTA on the Island of Hawai‘i have drawn on the guidance to help craft an approach for integrating climate considerations into the INRMP for this biologically diverse installation. Pohakuloa is home to large tracts of sub-alpine and dryland tropical ecosystems, with the latter being one of the rarest habitats in the world. To align with the overall INRMP update cycle, the team is using an “appendix-only” approach and plans to more fully integrate climate throughout the INRMP during the next formal revision.

The guide is also helping managers in Alaska, a state experiencing particularly rapid warming and unique climate-related threats like melting permafrost, as they update an Air Force INRMP addressing multiple installations, including some particularly vulnerable coastal sites. In New Hampshire, Army National Guard managers are using the guide’s INRMP adaptation planning framework to explore the changing climate’s effects and potential solutions.

Climatic changes are expected to amplify existing threats to DoD installations’ unique ecosystems and numerous rare species. Enhancing the resilience of threatened and endangered species to climatic and other threats on installations is an important focus of installation planning, consistent with FWS biological opinions. Active management to improve the resilience of these species includes invasive plant control, wildland fire management, predator removal, and genetic conservation actions for rare plants.

Installations across the country face varying climate concerns and management challenges, and no one-size-fits-all approach exists for climate adaptation. However, by helping managers understand the principles and processes underlying effective adaptation planning, the DoD climate adaptation guide serves as an important tool for enhancing installation resilience and maintaining military readiness.

Advances in climate change science are happening rapidly. A plethora of technical tools, scientific advances, information sources and websites, and DoD guidance have enabled some installations to move through the initial step of assessing exposure, followed by a subsequent period of beginning to evaluate vulnerability, culminating in an action-oriented phase of being able to develop and prioritize adaptation strategies and the integration of all that information with the INRMP along with associated objectives, activities and projects. Collectively, these efforts and the information making its way into INRMPs comprise a significant milestone toward climate resiliency for installations.

Implementing climate change considerations and integrating them with the INRMP does have its challenges, first and foremost being installation in-house expertise and staff capacity. Despite the availability of training, tools and state and federal agency resources, preparing the analysis is daunting. Most installations are not able to implement the Stein et al. (2019) 6-step guidance using in-house resources. Some installations may be able to implement some of the steps with assistance from cooperators and contractors. A few installations may be able to carry out the science and document integration in its entirety.

Currently the integration of climate change in the INRMPS is carried out both piecemeal by individual installations and through broad support agreements established by/through the military services.

INRMP review, revisions and updates

Annual reviews

It is DoD policy to review INRMPs annually[35]. This is an internal exercise that promotes use of the INRMP as a guiding document and facilitates a regular, albeit

[35] July 2015 Memorandum by the Deputy Assistant Secretary of Defense Environment, Safety and Occupational Health: Mutual Department of Defense & U.S. Fish and Wildlife

relatively informal, look at INRMP objectives, projects, and progress toward stated objectives. It also provides an important opportunity for an installation to connect and communicate with state and federal agencies that are INRMP signatories.

Annual reviews can be effective as part of the adaptive management cycle. However, they are commonly underutilized and/or underemphasized at the installation level. Inattention to cohesive annual reviews may reflect a lack of cohesion between the plan and program activities. INRMPS may be perceived as static documents lacking up-to-date, detailed information required for it to be considered a useful and authoritative document. Unfortunately, the “dust it off and update every five years” approach meets neither the intent of the driving legislation and policies nor installation needs.

Fortunately, many installations do enact procedures and expend effort to regularly revisit their INRMPs. The annual reviews consist of an internal process by installation staff, followed by outreach and communication with INRMP partners. Gibb (2005) found that few installations included in her study conducted activities related to maintaining and updating the INRMP. One of the best management practices identified by Gibb was the need for installations to establish a system for regular review and update of INRMPs vs. relying on individual managers’ note-keeping abilities to retain information until the next update or revision. In recent years, DoD and the military services have improved their emphasis on and support for regular and structured INRMP reviews and the maintenance of fully compliant INRMPS.

The author recently participated in an annual INRMP partners’ meeting held by the U.S. Army Garrison – Pohakuloa Training Area. The meeting was attended by staff from the Garrison, FWS, Hawaii state agencies and cooperators providing management support. The benefits and outcomes from this annual partner meeting are manifold. The meeting provided a forum to:

- Establish and nurture relationships with the partners (individually) on a professional level, or in the case of longer-term relationships, a personal level;
- Introduce/meet new staff members on cooperator, Army, and partner staffs;
- Discuss technical or other challenges, lessons learned, and problem solving/solutions;

Service Guidelines for Streamlined Review of Integrated Natural Resources Management Plan Updates.

- Discuss monitoring results and management implications;
- Review specific activities/projects, discuss results and address partner questions;
- Identify resources and explore the knowledge base among partners and other experts; and
- Identify opportunities for future collaboration and plan field outings/collaborations.

INRMP updates and revisions

Pursuant to the Sikes Act, INRMPs must be reviewed on a regular basis, but no less often than every five years, by DoD, FWS, NOAA Fisheries Service, and State fish and wildlife agencies. This review must be documented and signed by these parties. At a minimum, reviews shall assess conservation goals and objectives and the status of the natural resources conservation metrics described in DoDI 4715.03 (2011). According to DoDI 4715.03, "the requirement to review the INRMPs on a regular basis, but no less often than every 5 years, does not mean that every INRMP must be revised when it is reviewed. The Sikes Act specifically directs that the INRMPs be reviewed "as to operation and effect," emphasizing that the review is intended to determine whether existing INRMPs are being managed to meet the requirements of the Sikes Act and contribute to the conservation and restoration of natural resources on military installations in accordance with the Sikes Act."

A 2013 MOU between the DoD, FWS and AFWA regarding INRMP cooperation speaks to reviewing, revising, updating and implementing INRMPs for military installations. Related DoD Memorandum guidance in 2015 provides guidelines for INRMP review. The "Guidelines for Streamlined INRMP Review" do not apply to newly developed INRMPs or to INRMPs undergoing major changes (i.e., revisions). The processes established in the 2013 MOU and refined by the 2015 guidelines:

- Facilitate faster review and approval of INRMPs requiring updates;
- Reduce the number of non-compliant INRMPs; and
- Improve coordination and collaboration among installation personnel and FWS regional reviewers.

The 2015 Memorandum contains some key definitions to ensure consistency in discussions and procedures that generally agree with the 2013 MOU and FWS guidance:

<u>Compliant INRMP</u>: An INRMP that has been both approved in writing, and reviewed, within the past five years, as to operation and effect by authorized officials of DoD, FWS, and each appropriate State fish and wildlife agency.

INRMP Revision: Any new natural resources management actions necessitated by changes to the military mission, the condition of the land, or the status of the species present and not previously considered by the parties to the existing INRMP when the plan was last approved and/or reviewed as to operation and effect. All such revisions require approval by all parties to the INRMP and will usually call for a new or supplemental National Environmental Policy Act (NEPA) analysis, most commonly an Environmental Assessment.

INRMP Transmittal Letter: A cover letter to an INRMP update that summarizes changes to the compliant or operational INRMP.

INRMP Update: Any change to an INRMP that, if implemented, is not expected to result in consequences materially different from those in the existing INRMP and analyzed in an existing NEPA document. Such changes will not result in a significant environmental impact, and installations are not required to invite the public to review or to comment on the decision to continue implementing the updated INRMP. Updates do not change the management prescriptions set forth in the INRMP, and do not require analysis under the NEPA. The use of updates is intended to reduce the workload for all involved agencies while maintaining both INRMP currency and mission flexibility.

Operational INRMP: The most recent version of an installation's INRMP that was reviewed for operation and effect. The FWS will consider the INRMP currently being used to guide natural resource management on a given installation, irrespective of signature date, to be the operational equivalent of a compliant INRMP.

Nominal changes to activities would generally not trigger the need for a revision. Both the scope of the change in an activity and the scale of the change may inform the decision. There is no hard and fast rule on this decision; most commonly natural resources military service leads or their designees are involved in reviewing the INRMPs prior to signature, and would provide guidance to installations. Things that might trigger the need for a revision include changes to the mission, changes in the environment, and/or changes in management approaches or activities. More specific examples include the listing or new arrival of federally-listed plants or animals, the designation of critical habitat on the installation, addition or modification of ESA consultation requirements, significant changes to multiple-use management activities (e.g., grazing, timber, recreational, and agricultural programs), new arrival or changes in management activities for invasive plant and animal species, or any other significant change to the management prescriptions in the INRMP.

Once finalized, an updated or revised INRMP is considered reviewed for operation and effect and will restart the five-year window for compliance.

Monitoring INRMP implementation and effectiveness

Given that the deadline for initial INRMP preparation was in 2001, each installation has undertaken numerous annual reviews, a handful of updates, and perhaps a few revisions. The collective experience of many DoD natural resource managers as well as supporting staff, cooperators, contractors and DoD and military service specialists represents a vast source of knowledge with respect to INRMP development, implementation and evaluation. Some metrics for preparing and implementing INRMPs, first developed in 2002, are given in the 10 October 2005 Memorandum "Implementation of Sikes Act Improvement Act: Updated Guidance, issued by the Office of the Under Secretary of Defense."

The metrics are formal measures of merit for the conservation program. Progress towards meeting the measures of merit is reported in the annual Environmental Quality Report to Congress. Although those metrics can be useful for broad planning and budgeting purposes, unfortunately the emphasis of the metrics is not on ecosystem management or INRMP effectiveness, but rather on whether appropriate groups were consulted on the INRMPs, on the level of coordination with the review agencies, and on the budgeting and funding of INRMP projects.

One of the early efforts to improve the quality of INRMPs and how they are effectively implemented consisted of a two-day meeting in 2005, focusing on the INRMP structure and content and attended by representatives from the military services and DoD. The working group later developed recommendations to address shortcomings in the first round of INRMPS by applying their experience over the previous four years (USACE 2009). One of the outcomes was a revision of INRMP metrics developed by the Navy/Marines for the following topics:

(1) INRMP Implementation

(2) T&E Species and Critical Habitat

(3) Public Use & Outdoor Recreation

(4) Ecosystem Integrity

(5) Partnership Effectiveness (External stakeholders)

(6) Team Adequacy (Internal Stakeholders)

(7) INRMP Impact on the Installation Mission

DoD Instruction 4715.03, updated in 2013, included new and updated policy, natural resources conservation metrics, and procedures for DoD Components and installations for developing, implementing, and evaluating effective natural resources management programs.

From a high-level perspective, much emphasis is often placed on broad indicators such as the measures of merit described above. This is a form of implementation monitoring that is important and may infer the capability and resources to carry out the INRMP, but it will not enable managers to understand the effectiveness of individual projects or actions relative to individual resources or more holistic goals related to ecological communities and larger ecosystems.

There are other, directed and more specific, types of monitoring when it comes to INRMP effectiveness: 1. monitoring progress towards ecosystem management goals and objectives related to specific resources (i.e., condition and trends in resources compared to desired conditions); and 2. compliance monitoring related to specific metrics and thresholds specified in regulatory documents or laws (e.g., ESA compliance documents, Clean Water Act standards, no net loss of wetlands, etc.). In the absence of adequate management targets/objectives, effective monitoring is not possible or is done haphazardly. Effectiveness monitoring related to specific projects and activities continues to be one of the weakest aspects of INRMP development and implementation. See Chapter 2 for more on monitoring.

Key concepts and themes for a strong INRMP

The INRMP is the master document that integrates all projects, programs, activities and compliance commitments related to natural resources management on the installation. Partnership agreements and other commitments with entities outside the installation would also be captured and referenced therein. The INRMP must follow all applicable federal and state laws, regulations and policies, and should strive to meet the spirit of those documents as well. An excellent foundation for INRMP best management practices is presented in Gibb (2005a). However, considerations related to policies and legal aspects, on-the-ground environmental conditions, changing military missions, new ecosystem stressors, and new or innovative management approaches and tools continue to evolve over time.

The concepts and guidance within every chapter in this manual have bearing on the INRMP. The overriding themes of ecosystem management and its relationship to adaptive management and monitoring, support for training sustainability, conservation of imperiled species and their habitat at multiple scales, and the role of science-based management that recur and overlap throughout this guide must come together fully and in a cohesive way in the INRMP.

Successful INRMP implementation requires creativity and perseverance, with special attention to the following key elements:

Mission support—The INRMP should support and sustain military missions and strive to avoid any net loss to training capacity (i.e., what, when, where, and how often). By searching out and identifying win-win solutions for conservation and military training, the INRMP truly succeeds and by tying such projects and activities to training, funding chances are optimized.

Ecosystem management components (all)—The INRMP should explicitly incorporate and carry out the facets of ecosystem management, thereby paying attention to ecosystem health as well as the more charismatic INRMP components (see Chapters 1, 2, 8): 1) Develop a vision for the installation; 2) Identify and articulate goals and objectives (i.e., general and specific targets) for installation resources. These objectives should be specific, measurable, attainable, realistic/relevant and timely; 3) Conduct formal monitoring to measure progress toward goals and objectives; and 4) conduct adaptive management as needed to help refine management activities and redefine objectives/targets.

Multi-scale, proactive species management—Manage species, their habitats and the larger ecological systems and natural processes they depend on at multiple and nested scales over long-time horizons (see Chapters 1, 2, 8, 9). At-risk species must be identified and addressed more consistently and comprehensively to help avoid future ESA listings and associated compliance burdens on installations (see Chapters 1, 9 and DoD Species at Risk section this chapter).

Improving chances for funding—As pointed out by Gibb (2005a), because many (and for a few installations, the vast majority of) individual INRMP actions and projects are not considered “must fund,” they may fail to be funded if they are only presented as individual, noncompliance-related activities. To overcome this, the INRMP must clearly demonstrate the need for these individual actions and projects and must show how they are integral to successful INRMP implementation and their contribution to or necessity for sustaining the military mission support (see Chapter 7).

Improved linkages between actions/projects and goals and objectives based on desired condition of the training environments and biodiversity components can be introduced during INRMP updates and revisions. For example, excessive mechanized maneuver training in a particular location may result in sedimentation of aquatic systems, triggering a compliance problem with water quality, aquatic food webs, or TES, and ultimately restricting training activities. Without well-crafted resource objectives, the monitoring and adaptive management pieces are dysfunctional and inefficient.

Science-based management—Integrate the best available science from DoD and other state and federal agencies. Implement monitoring and research activities to support management. Develop and use a state and transition framework to facilitate management decisions, monitoring, and adaptive management with respect to prescriptions. The framework can help managers understand how ecological communities respond to drivers and disturbance, ecological thresholds of disturbance, and inform management objectives, and help design monitoring projects and interpret results. Military training disturbance can be integrated as a driver of change (see Chapter 2).

Go the extra mile—Strive for improvement over time. For example, even if your installation does not currently have critical habitat, review the criteria that determine if an INRMP provides adequate special management or protection to obviate the need for critical habitat designation (see section above on INRMPS and Critical Habitat Designation). This guidance, driven by the 2004 ESA amendment, sets a high bar for resource management and provides a framework to discuss this topic.

Unresolved issues related to INRMPS

Law Enforcement (Adapted from Ripley 2008)—The Sikes Act mandates that natural resources law enforcement be provided on military lands, and the DoD has developed very general law enforcement policy in DoD Directive 4715.3. However, comprehensive DoD law enforcement policy is lacking and each military service has historically addressed the subject individually on an installation-by-installation basis. This has included a range of law enforcement options ranging from employment of civilian game wardens, military police, or combinations of civilian game wardens and military police. Further, there is no DoD standard for law enforcement training, firearms, or civilian job descriptions. In 2003, the U.S. Marine Corps developed a standard law enforcement policy described in Marine Corps Order 5090.1, Conservation Law Enforcement Program.

The Marine Corps policy provides standardized job descriptions, prescribes training requirements, and sets staffing levels for all Marine Corps installations. Although the Air Force has endeavored to develop a similar program, it has yet to be formalized. A standard DoD policy on natural resources law enforcement, therefore, remains to be developed.

Public access to military lands (Adapted from Ripley 2008)—Public access to military lands for recreational purposes has long been a requirement of the Sikes Act. The Defense Authorization Act of 1999 expanded this requirement to specifically encourage access to hunting, fishing, and other outdoor recreation opportunities for disabled veterans. However, DoD policy has always stated that the local military commander has the authority to decide the extent of public access to his or her installation, based on security and safety considerations. And, following the events of 9/11, most military installations have significantly reduced public access. Consequently, no formal DoD policy exists for public access to military bases and ranges, and public access is handled mainly on a case-by-case basis at individual installations.[36]

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[36] See Chapter 11 for more on multiple uses of military lands.

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6. Partnerships to Achieve Conservation Goals and Sustain Training

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Introduction

This chapter describes the rise of partnerships as a conservation and training sustainment tool by DoD. It describes policies and guidance affecting the development and use of partnerships, highlights characteristics of successful partnerships, and provides examples.

The majority of military installations focused on training and testing were originally established during the mid-1900s in rural areas distant from urban centers. As small towns grew into larger urban areas and rural areas dominated by agriculture or undeveloped land became increasingly exurban and suburban, conflicts between military training (e.g., noise) and communities near installations have increased.

Partnerships are the primary overarching strategy used by the Department of Defense (DoD) to minimize the effects of encroachment arising from such conflicts and ensure that training missions can continue to be supported over the long term. Beyond resolving the encroachment issues faced by installations, partnerships benefit the participants by supporting their needs or mandates, be they conservation of agricultural lands and livelihoods, plants and animals and their habitats, watershed and water quality values, or biodiversity objectives. Partnerships can favor conservation of biodiversity at multiple scales. While this chapter focuses on partnerships, other policies, strategies, and tools for addressing encroachment are discussed in Chapters 2, 4 and 8.

The benefits of partnerships

It has long been DoD policy to encourage stakeholder cooperation on natural resources management issues to maintain and improve natural resources, as outlined in DoD Directive 4715.3. Prior to the enactment of 10 USC 2684a—which authorizes agreements to limit encroachments and other constraints on military training, testing, and operations—the Sikes Act was used as the primary authority for the Secretary of Defense to enter into cooperative agreements. However, Sikes Act authority was almost entirely directed to the protection of resources within the boundaries of DoD installations. The authority of 10 USC 2684a allows for cooperative conservation efforts through the acquisition of land or easements in the vicinity of military installations and ranges, thus adding much needed flexibility to wildlife protection efforts.

Finally, Executive Order No. 13352, Cooperative Conservation, specifically directs federal agencies to develop cooperative conservation programs. The term "cooperative conservation" is often used to describe collaborative efforts and partnerships to achieve conservation goals.

Over the years, cooperative conservation efforts with federal and state agencies, nongovernmental organizations, universities, and museums have provided many opportunities for the DoD to obtain invaluable, cost-effective research and other services in support of its natural resource conservation programs. With the authority of 10 USC2684a, many new cooperative agreements are being established that help to enhance off-base habitat and to ease encroachment problems in the vicinity of military installations.

At their best, efforts at public participation, conservation easements, and memoranda of understanding are examples of effective partnerships between the military and that part of the public that worries about conserving biodiversity. In such cases, "the public" can mean a small but concerned group of citizens who live near an installation, it can be a nationally known nonprofit organization that's interested in environmental protection, or it can be pretty much anything in between. There are many examples of partnerships currently in operation that promote conservation and further the military mission.

The U.S. Fish and Wildlife Service (FWS) within the Department of the Interior is one of two federal agencies responsible for managing the Endangered Species List, and so it is in constant demand for consultation by military land managers. Jane Mallory, former natural resource specialist at DoD's Legacy Resource Management Program, considers the FWS one of the best agency partners. Asked to define a successful collaboration, she said:

"There are several common themes that always come up with successful partnerships. One of them is to provide additional resources. It also enhances available expertise. It builds a network based on trust and teamwork. It facilitates sharing of information and nurture of natural resources. So with these goals in mind, of the successful partnerships we've had, the first one on my list is U.S. Fish and Wildlife Service. But we also have successful partnerships with other agencies—Bureau of Land Management, the Forest Service." Among nongovernmental agencies, Mallory puts The Nature Conservancy at the top of a lengthy list of organizations with conservation partnering expertise.

Mallory also feels that a successful partnership is one that brings with it additional resources—expertise, information, maybe even money—to a conservation plan.

Partnerships may be established at many levels—between the installation and nongovernmental organization, or university, or other governmental agency. What's important is the collaboration that the partnerships foster. Such a collaboration produces "a network based on trust and teamwork," says Mallory, and it "facilitates sharing of information." Partnerships to avoid, she said, are those in which the potential partners "have an agenda already, or they have their minds made up [negatively] about the Department of Defense." However, she adds that "It's exciting to people to find out that DoD does conservation and natural resources management."

It helps, say many natural resource managers, to set forth the rules of partnerships in writing. This is often done in a "cooperative agreement" or memorandum of understanding. Many of the buffering partnerships are created under MOUs. A typical agreement or MOU would explain:

- Why the agreement is necessary
- Why the parties to the agreement have been selected (or have selected themselves)
- The purpose of the agreement
- The responsibilities of the agreeing parties
- The financial understandings: Is any partner committing to the expenditure of funds?
- An understanding of how responsibilities and authorities are delegated and administered
- How the agreement may be modified and terminated

Box 6.1: Perspectives on conservation partnering teams (from Powledge 2008)

Steve Helfert of the FWS is a huge fan of what he and others call "conservation partnering teams," which provide a framework for productive partnerships. A major benefit of using such teams is that the structure practically guarantees "very strong communication lines" among its members. "A typical partnering team," he said, "would be a group that would agree to meet face-to-face, other than by telephone or e-mail. Meeting face-to-face could mean once a year, perhaps four times a year. An example would be the South Texas Natural Resource Partnership. They meet formally four times per year with a facilitator." The South Texas group, which covers an area that contains three military installations, takes matters a step further by making sure that installation commanders are part of their process. "They say, 'We want to add an annual executive briefing to our three installation commanders, to brief them on results of the prior year: what have we been doing, what have we succeeded in, what do we continue to do, what issues there are, what solutions.'" The result, he said, is that the conservation planners remain linked "to that component of the military we call the 'operations training and range' part of the military command—the folks in uniform who basically are training our troops. It's very important to stay engaged and linked with that."

In addition to creating a more formal conservation planning process and keeping commanders involved and up to date, the teams sometimes are good sources of ideas about how to find more money for biodiversity conservation. Who should the conservation partnership teams include? Helfert thinks that's one of the first questions the team must tackle. "I would advocate that if indeed there is a conservation partnering team or one in the making, then those local folks look at their local needs. They should ask, 'Do we need to bring in the county, the local school district, or other local governmental entities that may want to be part of a new partnership?' It may still be that you have just a core group of the military, Fish and Wildlife Service, and the state natural resources agency. They may be the nucleus of that group to look at any and all particular issues and solutions. Or sometimes the solution is to bring in more local folks as stakeholders or part of the team."

Helfert said it would not be unusual for the partnering team to seek out local groups, saying "You've got something we want you to bring to the table." Such an invitation would be obvious if encroachment is one of the problems facing an installation. The partnership team needs members "who are willing to think outside the military fence line. They think, 'Aha, the answers to these issues, including encroachment, obviously are going to involve outside players; I need to put on my beyond-the-fence hat and think externally.' I need to invite them in. I need to seek their wisdom, their input, if we're really going to tackle and solve this issue."

There are good examples of effective partnerships throughout the United States, and many of them are the product of conservation partnership teams, notes Helfert. "The important thing is we all like to think it's led principally by the military because we're focusing on military land," he said. "But it also could go off the [military] lands; it could go around the fenceline. And the leadership may change among the partners, depending on which initiative, which solution. But it's always going back to the tenet that it will benefit the military."

Characteristics of successful partnerships

In 2004, the FWS, Fisheries and Habitat Conservation program created the Military Conservation Partner Award to recognize military installations that have accomplished outstanding work in cooperation with the Service to promote conservation on military lands during the previous year. For example, in 2018, the award was given to Camp Blanding, FL. The FWS, the military and the Florida Fish and Wildlife Conservation Commission signed a Candidate Conservation Agreement with Assurances (CCAA) in 2017 to boost the base's conservation efforts and keep nearly two dozen at-risk fish and wildlife species off the Endangered Species list. Under the CCAA, landowners voluntarily commit to conservation actions to help stabilize or restore a plant or animal species. These activities collectively help to preclude the need for a threatened or endangered listing. In return, the military gets some regulatory certainty and a promise that, even if a plant or animal is added to the threatened or endangered list, training may continue[37].

The award was created to highlight the conservation benefits of partnerships between the military and the FWS, and to identify important criteria for selecting installations for the award. The following criteria categories, or some variation thereof relevant for a given partnership, can be helpful to installations when building conservation partnerships large and small[38].

<u>Communication and cooperation with partners (area of highest emphasis)</u>

- Describe the types of contact the installation maintains with the FWS, state agency and other stakeholders.
- What natural resource management teams has the installation developed?
- What Memoranda of Understanding or cooperative agreements has the installation implemented?
- List unique outreach activities and public involvement
- Have team members received any other awards for their partnerships?

<u>Issues resolution, success and effectiveness</u>

- Are issues resolved with a regional ecosystem management perspective?
- Give examples of successful issue resolution and coordination with all parties
- How has the installation's natural resource program benefited the resource?
- Is project success and effectiveness ongoing?

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[37] https://www.fws.gov/southeast/tags/military-conservation-partner-award/

[38] https://www.fws.gov/habitatconservation/Award_Form.pdf

- Creative projects or solutions to issues
- Do projects have a regional- or landscape-level impact? Projects listed may be on or off the installation
- What unique natural resource projects have been implemented?
- Are projects proactive?

<u>Program diversity</u>

- Describe the diversity of the natural resource program; include examples of recreational fisheries, hunting, endangered species, habitat restoration, migratory bird, invasive species, watershed management, wetland restoration, and other projects
- Who conducts the work? Installation staff, contractors, cooperators/non-federal entities?

<u>Service policy and regulation compliance</u>

- Is the INRMP up to date with Service concurrence within the past five years?
- Were INRMPs and other documents submitted with enough time for FWS review?
- Were natural resources compliance projects resolved in a timely fashion?
- Were section 7 consultations adequately and timely submitted?
- Was NEPA coordination and documentation completed on schedule?

The Readiness and Environmental Protection Integration (REPI) Program has developed a series of primers designed to facilitate a better understanding among partnership stakeholders, including military installation leadership, state, regional and local government officials, land trusts, and communities. These primers provide tools and suggestions for establishing and maintaining effective relationships and partnerships to address the challenges of encroachment, but are relevant to other partnerships as well (more on REPI below). The following primers are available for download from the REPI website[39]:

- Collaborative Land Use Planning: A Guide for Military Installations and Local Governments

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[39] https://www.repi.mil/Resources/Primers.aspx

- Commander’s Guide to Community Involvement
- Commander’s Guide to Renewable Energy
- Commander's Guide to Understanding and Supporting Working Forests
- The Department of Defense’s Readiness and Environmental Protection Integration (REPI) Program Buffer Partnerships
- Outreach for Mission Sustainability: Working to Balance Military and Civilian Community Needs
- Working to Preserve Farm, Forest and Ranch Lands: A Guide for Military Installations
- Working with Conservation Districts: A Guide for Military Installations
- Working with Land Trusts: A Guide for Military Installations and Land Trusts
- Working with Local Governments: A Practical Guide for Installations
- Working with Regional Councils: A Guide for Installations
- Working with State Legislators: A Guide for Military Installations and State Legislators

Guidance on the essential elements and lessons learned by participants in the Sonoran Desert Ecosystem Initiative are particularly relevant to this discussion (Chambers and Hall 2005). The project’s relatively long timeframe (1998 to 2005), large geographic scope (Sonoran Desert Ecoregion’s 55 million acres), and diverse partnerships involving many federal and state agencies, universities, and nonprofit conservation organizations make it particularly rich in lessons that can be applied to future work. Lessons learned are organized into three main categories: (1) partnerships, (2) results, and (3) public involvement. Within each category, the authors describe lessons first in general terms and then provide examples from the Initiative.

Types of partnerships

Day-to-day partnering (i.e., collaboration) at the installation level

Installation natural resource managers engage regularly with professional peers, civilians and military personnel on installations. These relationships and engagements build trust through effective communication, inclusion of the right people in the process, effective collaboration and sharing of common installation support goals. The primary partners within the installation are other offices, divisions, branches, departments, and sections, etc. within the directorate or program that governs natural resources management and environmental compliance; installation master planning; offices/departments responsible for safety; installation fire department; range and training departments and range planning offices, including Range Control or Range Operations and the Integrated Training Area Management (ITAM) Program; law enforcement; the installation commander/command group; public affairs office and others.

Attention to these entities and the civilians and military personnel supporting them in a regular and inclusive way pays dividends when it comes to achieving conservation objectives, especially those involving win-win scenarios with training sustainability and support. As the military staff often turn over every few years (with the exception of the National Guard Bureau, where military personnel may remain for decades), it is especially important to reach out regularly to sustain relationships, build trust, and meet new personnel.

Partnerships supporting discrete planning, management and compliance

Successful development and implementation of comprehensive planning and compliance documents often hinges on successful participation and partnering with other agencies, offices and individuals outside of the installation natural resources staff group. Effective public engagement may also be involved. Such activities include ongoing informal communication and consultation with federal and state agencies and other partners and stakeholders, or collaboration and consultation that is more formal and focused on discrete plans, compliance documents, and other documents.

Integrated Natural Resources Management Plans (INRMPs), Biological Assessments, and Integrated Wildland Fire Management Plans and many other documents require elements of effective partnering to ensure they are scientifically sound, balance competing interests and can be implemented effectively. For example, in accordance with Sikes Act requirements, collaboration with federal and state agencies is required as part of periodic INRMP updates as well as internal annual reviews by the installation (see Chapter 5 for more details). The agency partners typically involved in said reviews include, at a minimum, regional FWS staff and one or more state agencies responsible for natural resources, fish and wildlife. The development of conservation partnering teams is most commonly associated with threatened and endangered species planning, management and compliance (see sidebar by Powledge (2008).

Buffering umbrella: minimizing encroachment and conflict, sustaining training

Training restrictions, costly workarounds, and compromised training realism can result from incompatible development surrounding the installation (external encroachment) and from threatened and endangered species on the installation (internal encroachment). In 2003, Title 10, Section 2684(a) of the U.S. Code authorizes the DoD to form agreements with non-federal governments or private organizations to limit encroachments and other constraints on military training, testing, and operations by establishing buffers around installations. An assessment of DoD’s Readiness and Environmental Protection Initiative (REPI) program to buffer installation encroachment is presented by Lachman et al. (2007). In their evaluation, Lachman et al. identified numerous benefits of buffering as related to conserving habitat and environmental quality as well as community relationships and partnerships. Examples of benefits include:

1) Preserving habitat, biodiversity, and threatened and endangered species by helping to protect habitat, wildlife corridors, biodiversity, and ecosystems; helping protect and sustain threatened and endangered species off base; and helping to keep at-risk species off the federal threatened and endangered species list.

2) Water benefits, including protecting watersheds and ameliorating water quality and quantity concerns.

3) Strategic landscape, regional, and ecosystem management and planning. For example, buffering can help protect broader ecosystems at ecoregional scales (e.g., Gulf Coastal Plain Ecosystem Partnership and Central Shortgrass Prairie ecoregion).

4) Other environmental benefits such as improvement of installation environmental management and increased education and awareness for local governments and communities about the need for ecosystem protection and management.

5) Community relations benefits for the installation and military, such as improved relations with environmental groups, regulators, state and local governments, and landowners; improved installation public communications process; and improved environmental and overall reputation of the installation.

6) Working partnerships benefits such as improved working relationships with partners in both buffering projects and other activities; and helping to foster more collaborative approaches to conservation in the region.

7) Improved internal installation collaboration and management such as improved installation management attitudes about collaboration with nonmilitary organizations, and improved collaboration and relationships between training and environmental staff.

The process to establish a conservation easement on buffer lands varies with each military service, partnership, and local real estate condition. Typically, a land conservation trust organization purchases lands from the owner with funds contributed by the military and the participating partners. In exchange, the military service receives a restrictive easement or other assurances that the property will be perpetually protected. Proposed development or land use changes on easement lands need DoD service approval to ensure compatibility with the mission[40].

Early DoD examples: The Army led this movement in the 1990s by acquiring conservation easements on lands around Fort Bragg, NC, that were suitable habitat for the Red-Cockaded Woodpecker.[41] The Army eventually expanded and formalized this strategy into the Army Compatible Use Buffer (ACUB) Program. The Marine Corps followed soon after by acquiring easements on land adjacent to its Marine Corps Base Camp Lejeune, also in North Carolina.

Cooperative partnerships have grown in subsequent years to the point where they are everyday instruments in the military land manager's toolbox. The Fort Carson Regional Partnership is helping to protect what remains of Colorado's short-grass prairie and the flora and fauna that inhabit it. The Coastal Georgia Private Lands Initiative was established by Fort Stewart and Hunter Army Airfield and their partners to protect some 120,000 acres surrounding the base.

And a well-known and celebrated conservation partnership is the Northwest Florida Greenway[42], a consortium of military, government, and nonprofit organizations that seeks to protect a hundred-mile-long protected corridor of valued biodiversity that connects Eglin Air Force Base and the Apalachicola National Forest. The Greenway partners include DoD, Florida Department of Environmental Protection, Okaloosa Economic Development Council, Air Force Air Armament Center, and the Nature Conservancy. The partnership region has been identified as one of the six most biologically diverse regions in the United States.

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[40] U.S. Department of Defense and U.S. Fish and Wildlife Service. 2004. Fact Sheet: Conservation Lands as Compatible Use Buffers.

[41] For more on conservation easements, see The Nature Conservancy Web site at https://www.nature.org/en-us/about-us/who-we-are/how-we-work/private-lands-conservation/

[42] http://www.cooperativeconservation.org/viewproject.aspx?id=656

Army Compatible Use Buffer (ACUB) Program[43]

The Army implements DoD's authority to form agreements with non-federal governments or private organizations for buffering purposes through the ACUB program, which is managed overall at Army Headquarters level by the office of the Deputy Chief of Staff for Installations. Active Army cooperative agreements are managed by U.S. Army Environmental Command (USAEC) (a subordinate of the U.S. Army Installation Management Command or IMCOM), and Army National Guard Directorate ACUB cooperative agreements are managed by the Army National Guard Environmental Programs Division.

The ACUB program allows installations to work with partners to encumber off-post land to protect habitat and buffer training without acquiring any new land for Army ownership. Through ACUB, the Army reaches out to partners to identify mutual objectives of land conservation and to prevent development of critical open areas. The Army can contribute funds to the partner's purchase of easements or properties from willing landowners. These partnerships preserve high-value habitat and limit incompatible development in the vicinity of military installations. Establishing buffer areas around Army installations limits the effects of encroachment and maximizes land inside the installation that can be used to support the installation's mission.

Across ACUB Programs at over 40 separate installations, as of September 31, 2019, the Army has protected 390,903 acres of natural habitat, open space, and working lands through its cooperative agreements with more than 50 partners ranging from large, nationwide land trusts to smaller local conservation entities, to state and municipal governments. Total ACUB transactions (942) equate to over a billion dollars ($1,067,240,000), which includes not only the cost of the land or conservation easements themselves, but also various other allowable and authorized tasks such as due diligence, monitoring and enforcement, and land management actions. This expenditure total includes $278.74 million from the DoD Readiness and Environmental Protection Integration (REPI) Program, $305.31 million in Army service dollars, and $483.18 million in partner contributions (both cash and in-kind services).

Partner share varies across all the individual ACUB cooperative agreements, but cumulatively, ACUB partners are contributing approximately 45% ($483.18M of $1,067.24M) of the total program cost.

DoD Readiness and Environmental Protection Integration Program

The DoD's REPI Program is a key tool for combating encroachment that can limit or restrict military training, testing, and operations. The REPI Program protects these

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[43] https://aec.army.mil/index.php/conserve/ACUB

military missions by helping remove or avoid land-use conflicts near installations and addressing regulatory restrictions that inhibit military activities. The REPI Program is administered by the Office of the Secretary of Defense.

A key component of the REPI Program is the use of buffer partnerships among the military services, private conservation groups, and state and local governments, authorized by Congress at 10 U.S.C. § 2684a. In November 2020, the REPI website listed and profiled 36 buffering projects on Army lands, 31 on Navy lands, 9 on Marine Corps lands, 22 on Air Force lands and 11 on Joint Bases. These win-win partnerships share the cost of acquisition of easements or other interests in land from willing sellers to preserve compatible land uses and natural habitats near installations and ranges that helps sustain critical, at-risk military mission capabilities. Detailed program description, resources, fact sheets, project profiles, the REPI Metrics Report, and annual REPI Reports to Congress are available at the REPI website[44].

REPI also supports large landscape partnerships that advance cross-boundary solutions and link military readiness, conservation, and communities with federal and state partners through a common, collaborative framework. Such partnerships include the Southeastern Regional Partnership for Planning and Sustainability and the Western Regional Partnership. REPI also participates in the Sentinel Landscapes Partnership between DoD and the Departments of Agriculture and the Interior.

In addition to buffering projects, REPI also develops and transfers lessons learned from innovative strategies and pilot projects that address regulatory barriers and constraints, such as projects focusing on off-installation habitat conservation to meet on-installation Endangered Species Act obligations. Other activities include hosting educational webinars and range tours, publishing primers focused on a variety of stakeholder groups and encroachment issues, and providing additional resources to support the military services.

Since its first partnerships in 2003, REPI has grown and fostered a sea change in how DoD responds to conservation and military training issues and engages in outside-the-fence land use planning. Engaging with all stakeholders at the federal, state, and local level, REPI continues to explore policy and regulatory solutions to incompatible development, off-installation species habitat, and other mission sustainability issues.

[44] https://www.repi.mil/

Sentinel Landscapes

The Sentinel Landscapes Partnership is a coalition of federal agencies, state and local governments, and nongovernmental organizations that works with private landowners to advance sustainable land management practices around military installations and ranges. Founded in 2013 through an MOU by the DoD, Department of Agriculture (USDA), and Department of the Interior (DOI), the partnership connects private landowners with voluntary government assistance programs that support defense, conservation, and agricultural missions[45]. In 2018, the National Defense Authorization Act (NDAA) introduced language that formally recognized the Sentinel Landscapes Partnership in statute.

Leadership from the three founding agencies coordinate the partnership at the national level through the Federal Coordinating Committee (FCC). The FCC consists of representatives from DoD, USDA's Natural Resource Conservation Service (NRCS), the U.S. Forest Service (FS), the Farm Service Agency (FSA), the FWS, and the Bureau of Land Management (BLM). The FCC designates locations as sentinel landscapes and then works to connect private landowners with government assistance programs that fund land protection and natural resource restoration projects. By aligning these programs in sentinel landscapes, USDA, DoD, and DOI use taxpayer dollars more efficiently and accomplish more on the ground with fewer resources. The vast majority of DoD funding for Sentinel Landscapes comes from the DoD REPI Program.

Since its beginning, the Partnership has leveraged $141 million in DoD funds with $223 million in USDA funds, $41 million in DOI funds, $169 million in state funds, $15 million in local funds, and $80 million in private funds to support partnership projects. These contributions have protected over 467,000 acres of land and implemented sustainable management practices on 2.3 million acres around high-value military testing and training areas[46]. There are currently seven Sentinel Landscapes that encompass a broad representation of continental U.S. biogeography: Avon Park Air Force Range (Florida), Camp Ripley (Minnesota) (see Camp Ripley Sentinel Landscape Case Study within this Guide), Eastern North Carolina, Fort Huachuca (Arizona), Georgia, Joint Base Lewis-McChord (Washington), and Middle Chesapeake (Maryland).

A recent examination of DoD conservation programs concluded that greater funding for REPI and more ambitious implementation of the Partnership would enhance local

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[45] https://sentinellandscapes.org/

[46] 2020 Sentinel Landscapes Accomplishments Report, available at https://sentinellandscapes.org/about/resources/

land use decisions that protect conservation resources near installations, expand land acquisition by other agencies in DoD's priority areas, and incentivize private landowners to promote conservation and national defense (Li and Male 2020). Moreover, as development marches into areas surrounding installations, larger parcels become fragmented and real estate values climb, thereby eroding the value of funds available to manage encroachment over time (Lachman et al. 2007).

Examples of conservation partnerships

Some programs focus at the local level while others address national issues, targeting conservation across DoD managed lands; some others are state or regional in scope. Here are just a few examples of the wide variety of DoD conservation partnerships across military services and geographic regions. DoD contributes to numerous partnerships and provides funding sources. Its involvement and support for such programs reflects a shift in DoD over the past several decades from an inward-gazing perspective to an outward-gazing one that proactively seeks partnerships (Li and Male 2020).

The DoD Partners in Flight (PIF) program

The DoD's PIF program sustains and enhances the military testing, training, and safety mission through proactive, habitat-based management strategies that maintain healthy landscapes and training lands. DoD is an active partner in both the international PIF[47] coalition and the U.S. North American Bird Conservation Initiative[48]. DoD PIF representatives assist installation natural resources managers in improving monitoring and inventory, research and management, and education programs involving birds and their habitats.

The DoD PIF Strategic Plan identifies actions that support and enhance the military mission while also working to secure bird populations. These actions can be incorporated into installations' Integrated Natural Resources Management Plans (INRMPs) and Bird/Animal Aircraft Strike Hazard plans (Eberly and Keating 2006). DoD PIF works beyond installation boundaries to facilitate cooperative partnerships, determine the current status of bird populations, and prevent the listing of additional birds as threatened or endangered. DoD PIF provides a scientific basis for maximizing the effectiveness of resource management, enhancing the biological integrity of DoD lands, and ensuring continued use of these lands to fulfill military training requirements. By identifying species of concern and managing habitats for those species, future listings can be minimized or eliminated.

[47] https://partnersinflight.org/

[48] https://nabci-us.org/

The need for PIF is driven by ecological imperatives as well as Federal legislation such as the Migratory Bird Treaty Act, Executive Order No. 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds), and the “military readiness rule” (50 C.F.R. §21.15), which require impact analysis of military readiness and non-readiness activities on migratory birds.

DoD Partners in Amphibian and Reptile Conservation (PARC)

The DoD’s PARC[49] program launched in 2009 to provide leadership, guidance, and support for the conservation and management of amphibians and reptiles on DoD lands in ways that help sustain military testing, training and operational mission activities.

DoD PARC was established in response to dramatic declines in amphibian and reptile populations and the potential resulting impact to mission readiness. Under PARC, DoD established a network of installation natural resources managers to communicate and collaborate among each other and with a national network of partner organizations.

DoD PARC is voluntary, proactive, and non-regulatory, and consists of military and civilian personnel. The purpose of this network is to implement proactive, habitat-based management that enables readiness by working in partnership with all relevant groups to promote actions that minimize encroachment factors while helping sustain wildlife populations. DoD PARC does this by providing cutting edge scientific information and management recommendations that help preclude or minimize training restrictions due to species endangerments; by providing extensive outreach and education to installation personnel and to the public; and by working closely with all stakeholders, including the test and training communities.

Since its creation, DoD PARC has partnered with over 50 federal and state agencies, universities, zoos, and nongovernmental organizations to prevent species declines both on and off DoD lands. DoD PARC regularly partners with the national PARC network, the nation’s largest and most comprehensive conservation effort ever undertaken for amphibians and reptiles. By working in partnership, DoD is able to leverage knowledge, skills, and resources to alleviate constraints to the military mission, and further conservation and recovery goals for imperiled species. DoD PARC’s focus also includes overseas military lands owned or leased by the U.S. and/or at which U.S. military personnel are stationed.

[49] https://www.denix.osd.mil/dodparc/home/index.html

Box 6.2: PARC partnership success stories[50]

Flat-tailed Horned Lizard (FTHL)

In 1997, multiple federal and state partners, including from the U.S. Marine Corps (USMC) and U.S. Navy, signed a voluntary long-term Interagency Conservation Agreement to use common management goals and strategies to prevent the FTHL from being federally listed. The FTHL lives on roughly 153,000 acres of training lands on Naval Air Facility El Centro and the Barry M. Goldwater Range West in California. The FTHL was first considered for listing under the Endangered Species Act (ESA) in the 1980s; however, as a result of the partnership's voluntary conservation efforts[51], the FTHL is not only thriving on military lands, but the FWS has determined listing the FTHL is not warranted.

Mohave Desert Tortoise

As a result of multiple stressors, the Mohave Desert Tortoise was federally listed under the ESA as threatened throughout its range in 1994. This listing has required significant workarounds for training and exercises in the region, and DoD has spent nearly $150 million in response[52]. So, when the USMC needed to expand the Marine Corps Air Ground Combat Center 29 Palms training area, installation biologists worked with a team of highly qualified partners in the Southwest to plan the relocation of approximately 1,100 Desert Tortoises[53]. Similar and costly planning, logistics, and conservation measures for the species had to be implemented for Fort Irwin's land expansion, Operation Citadel Shield, and Naval Air Weapons Station China Lake's recent land expansion.

Western Pond Turtle

The Western Pond Turtle has declined across nearly 80 percent of its range (Rhodin et al. 2010), and is the only remaining native freshwater pond turtle in California.

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[50] OSD Commander's Guide to the Department of Defense Partners in Amphibian and Reptile Conservation Network. 2020. https://www.denix.osd.mil/dodparc/home/index.html

[51] Flat-tailed Horned Lizard Interagency Coordinating Committee. 2003. Flat-tailed Horned Lizard Rangewide Management Strategy, 2003 Revision. US Fish and Wildlife Service, Carlsbad, California

[52] From FY1991-FY2016, DoD spent $143M on the desert tortoise.

[53] https://www.defense.gov/Explore/News/Article/Article/1152478/marinesrelocate-desert-tortoises/

Recently split into two species taxonomically, the USMC is a significant stakeholder for the Southwestern Pond Turtle. Both it and the Northwestern Pond Turtle are currently being considered for listing by the FWS, which could result in mission impacts. Pro-active conservation actions have been implemented and more are planned to recover these imperiled species and avoid potential regulatory protections by a listing under the ESA. To achieve maximum success, DoD is working with over a dozen state and federal partners through a range-wide conservation coalition to implement a Rangewide Management Strategy for these conservation actions.

Longleaf Amphibian and Reptile Conservation (ARC) Project

Through the national PARC network, DoD became a member of the Longleaf ARC Project, which is focused on accelerating conservation efforts for five at-risk species (Gopher Frog, Gopher Tortoise, Striped Newt, Southern Hog-nosed Snake, Florida Pine Snake) that live in longleaf pine habitats. If these at-risk species were to become listed under the ESA, it could impact training on more than 30 southeastern installations. Project partners are gathering data to improve decisions about where and how to invest conservation resources to ensure the greatest return on investment. Already through these efforts, the Southern Hog-nosed Snake was determined to be “not warranted for protection” under the ESA.

Pollinator Conservation on DoD Lands

In 2015, a Memorandum of Understanding between the DoD and the Pollinator Partnership was created to establish a framework for cooperative programs that promote the conservation and management of pollinators, their habitats and associated ecosystems. The framework for cooperation and coordination is especially important to ensure that pollinator management activities are incorporated, where practicable, into installation integrated natural resource management plans (INRMPs) and practices.

Onslow Bight Conservation Initiative[54]

This partnership seeks to protect environmentally sensitive terrain and wetlands around Marine Corps Base Camp Lejeune. Coastal North Carolina’s Onslow Bight stretches from Cape Lookout to Cape Fear. A rich mosaic of saltwater marshes, wetlands, longleaf pine savannahs, and other coastal ecosystems, it supports several rare and endangered plant and animal species, including the Red-cockaded Woodpecker. The region is developing rapidly and beginning to lose its rural character and ecological integrity. The Onslow Bight Conservation Forum was jointly initiated by The Nature Conservancy and Camp Lejeune in response to

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[54] http://www.cooperativeconservationamerica.org/viewproject.aspx?id=727

encroachment issues at the military installation. Most of the partners own land in the region. Partners represent a broad spectrum of land managers and conservation advocates who are working to identify areas that should remain natural, develop political support for land acquisition, and work toward acquiring these lands.

Box 6.3: Air Force Wildland Fire Branch (AFWFB): Interagency coordination and partnership to manage wildland fire threats

By Michelle Steinman, Air Force Civil Engineer Center Environmental Directorate, Wildland Fire Branch, originally published in the Fall 2020 edition of "Natural Selections," the newsletter of the DoD Natural Resources Program[55].

Wildfire risk has dramatically increased, particularly in the western United States, as a result of changing climatic conditions. Warmer temperature trends, along with increased periods of drought, are exacerbating large and intense wildfire outbreaks. Unplanned wildfires on installations not only lead to devastating impacts to infrastructure and natural resources, but also threaten the military mission. DoD focuses on wildfire management as an important component of installation planning and resilience. In particular, the Air Force is at the forefront of creating a structured process that effectively coordinates with stakeholders to successfully mitigate and manage wildfires.

The Air Force established the AFWFB under Civil Engineering Transformation to specialize in managing wildland fire threats. Since 2012, the AFWFB has grown into an interagency network of nationally qualified wildland firefighters. The group is focused on enabling mission readiness by maintaining ecosystem integrity and mitigating wildfire risk at Air Force installations. AFWFB has over 80 staff members, including wildland fire experts from the Air Force, the FWS, Colorado State University (CSU), the Bureau of Land Management (BLM), the Forest Stewards Guild, and the University of Montana. Headquartered at Joint Base San Antonio, TX, the AFWFB's responsibilities include developing policy and guidance; leveraging partnerships with land management agencies; issuing and certifying National Wildfire Coordinating Group qualifications; collecting and analyzing wildland fire data, and vehicle and equipment authorizations; and developing wildland fire management plans.

Field support is a key component of the AFWFB's strategy with 14 strategically placed Wildland Support Modules (WSMs). WSMs are made of up to 12 wildland fire experts with a suite of vehicles and equipment. The WSMs focus on executing

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[55] https://www.denix.osd.mil/nr/

hazardous fuel reduction projects that support each installation's unique INRMP and Wildland Fire Management Plan, thus increasing the installations' resilience to wildland fire. The WSMs have facilitated better working relationships between natural resources managers and fire and emergency service (FES) personnel who have collectively reduced hazardous fuels on over 130,000 acres through prescribed burns and brush removal each year. As a qualified and capable resource, the WSMs supplement FES and mutual aid wildfire response to more than 100 wildfires annually.

The interagency makeup of the AFWFB allows for sharing resources and improving competencies across all agencies. Personnel gain critical on-the-ground experience with fire behavior across a variety of fuel types and weather conditions. Prescribed burns are one example of important interagency collaboration to prevent wildland fires. Prescribed burns reduce the amount of excessive vegetation on the forest floor, encourage the growth of native vegetation while killing off invasive species, and maintain plant and animal species habitats that depend on periodic fires. Recently, the Ellsworth AFB WSM, including the installation's natural resources and FES personnel, partnered with the National Park Service (NPS) and Box Elder Volunteer Fire Department to complete a 273- acre prescribed burn on the installation. The burn improved management of natural habitats and rangeland conditions, while reducing the hazardous fuel load. Prescribed burns also increase an installation's resilience through reducing the risk of a wildland fire outbreak. Ellsworth WSM and FES also assisted the NPS and FWS with a 260-acre prescribed burn at Mount Rushmore National Memorial.

AFWFB will continue leading efforts to minimize wildfire risk, reduce hazardous fuel at Air Force installations, and identify new opportunities for collaboration. The Branch is well positioned to develop wildland fire management guidance in response to changing environmental conditions. This guidance is important to maintaining healthy landscapes and mission readiness. Predicting and preventing wildfires supports resilience across the Department as installations work to avoid damage to critical infrastructure and equipment, as well as reduce mission impacts.

Gulf Coastal Plain Ecosystem Partnership[56]

Florida's Western Panhandle is one of the most rapidly growing areas in the Nation; its pristine coastal region is under intense development pressure. Rapid growth and the loss of green space are creating serious encroachment issues for Eglin Air Force Base (AFB), Naval Air Station Pensacola (NAS), and NAS Whiting Field. The most

56 http://www.cooperativeconservationamerica.org/viewproject.asp?pid=544

serious issues include concerns about low-level flights and weapons testing in the face of encroaching development.

From a conservation perspective, the area includes the largest remaining stands of natural longleaf pine forests and some of the last undeveloped coastline on the Gulf Coast. The pine forests shelter rare and listed species, including one of the largest population of the [previously endangered and now federally-threatened] Red-Cockaded Woodpecker. Conservation organizations have concerns about timber production and sustainable forestry, outdoor recreation, conserving biodiversity, wildlife management, and protecting water resources.

The Gulf Coastal Plain Ecosystem Partnership (GCPEP), formed in 1996 via a Memorandum of Understanding, launched a joint planning process to identify conservation goals and actions, and to provide buffers for military lands. Nongovernment partners have contributed funds and office space, and have provided volunteers, public outreach, and other services. To date, the partnership has protected over one million acres.

<u>Sonoran Desert Ecosystem Initiative</u>

This Initiative protects the desert ecosystem in a 55-million-acre area in Arizona, California, and the Mexican states of Sonora and Baja California Norte. The U.S. portion of the Sonoran Desert is dominated by federally managed lands. Collectively, these lands are adversely impacted by human population growth-related impacts of increased development and fragmentation of natural landscapes. Because it is a rapidly growing region, the extent of these impacts on the region’s biological resources is likely to intensify. These human-related disturbances also accelerate the spread of invasive plants, which is one of the most serious threats to the persistence of Sonoran Desert native ecosystems. In addition, as the landscape becomes fragmented and otherwise degraded by incompatible human activities, the effects of long-term drought on desert species are exacerbated.

To address the above challenges, the Sonoran Desert Ecosystem Initiative (hereafter the Initiative) was designed by The Nature Conservancy and The Sonoran Institute and funded by the DoD Legacy Resource Management (Legacy) Program and Bureau of Land Management. The principle objectives of the project were to: provide a proactive approach to conservation planning that focuses on conserving native biodiversity and ecological processes within a federal land management context; encourage coordination of management activities across jurisdictional boundaries to address mutual resource management objectives; and facilitate partnerships to increase each agency’s ability to accomplish its mission while meeting its stewardship mandates.

The Initiative focused on three connected components: monitoring the ecosystem and coordinating management; biodiversity management that is tailored to specific sites “and [that also] provides model lessons to apply to other sites . . . across the region”; and management of invasive plants, which are a major threat to the desert ecosystems.

Educational Institutions

Educational institutions are important DoD partners in the effort to conserve biodiversity. The Cooperative Ecosystem Studies Units (CESU) provide research, technical assistance, and education to federal land management agencies and their partners. Involvement by educational institutions is primarily through research funded by DoD and other grants, cooperative agreements to support installation needs through staffing and other applied support, and other involvement as subject matter experts. Educational partners bring expertise and capacity in support of military land management. See Chapter 7 “Funding Natural Resources Conservation on Military Lands” for a discussion of contracts and cooperative agreements that enable university support of DoD biodiversity management needs.

Universities bring a wide range of expertise to the table. Familiarity with a region or locality can make universities indispensable due to their knowledge of specific ecosystems and species, the natural processes that sustain them, and their response to various disturbance agents and regimes. Management and planning no doubt benefit from such local or regional knowledge. Some universities have specialized knowledge and experience with military land management and operating on an installation. The most robust and far-reaching of such programs is The Center for Environmental Management of Military Lands at Colorado State University. The program has a core staff with broad and specialized expertise in natural and cultural resources and environmental compliance disciplines, and provides technical support to DoD installations, military services and headquarters via research, applied science and planning, and extensive DoD staffing support across the Continental United States (CONUS) and outside of the Continental United States (OCONUS).

Similar, albeit smaller programs that generally focus on support to installations closer to home exist at several other universities such as Texas A&M University (Natural Resources Institute), Virginia Polytechnic Institute and State University a.k.a. Virginia Tech (Conservation Management Institute), and The University of Montana (Center for Integrated Research on the Environment). From the military’s perspective, the ideal university partner (or other cooperator or contractor, for that matter) will have a proven credentials that include expertise in subject matter, the procedures required to execute the project, and familiarity with working on military lands (e.g., access, security/safety, planning, military missions/training, military organizations and structure). Comprehensive knowledge of military lands management is requisite for military-specific work such as Integrated Natural Resource Management Plans, NEPA documents, and other support.

Partnerships between universities and DoD entities are mutually beneficial, and can fit especially well with Land Grant Universities with missions that include teaching, research and extension. Importantly, university support to military conservation efforts can include students at all levels. Applied projects are thus executed while providing hands-on experience to undergraduate and graduate students. There are ample opportunities for research, and much of that is funded by grants from various sources, some associated with DoD (see Chapter 7 “Funding Natural Resources Conservation on Military Lands” for more on funding sources). In some cases, installations may partner with academic institutions to complete research that would benefit installation resource management or conservation. In other cases, academics pursue research grants where the study site or resource of interest is on military lands. Pre-coordination and approval to conduct the research would obviously be needed for the researcher to proceed. Such research arrangements can provide unique opportunities for researchers and expand the body of scientific knowledge needed by natural resources managers.

Box 6.4: Leveraging university support for rare species of the New Jersey Pinelands (from Powledge 2008)

An example of the value of universities in partnerships may be seen at the Warren Grove Gunnery Range, a 9,416-acre Air National Guard facility situated in the New Jersey Pinelands. The Pinelands, which include the ecologically famous New Jersey Pine Barrens, form an ecosystem that historically has been characterized by periodic fires. When the gunnery range started compiling its Integrated Resources Management Plan, it needed answers to the basic question: Were the range’s activities compatible with the best biodiversity conservation methods?

Fortunately for the range, Drexel University was an eager research partner. It was a match made in heaven: Warren Grove needed conclusive scientific studies, and Drexel’s Department of Bioscience and Biotechnology had dozens of students eager to do them. Drexel also had Walter F. Bien, the director of Pinelands research at the university and a native of the region.

“I guess we’ve done close to a dozen ecological studies since around 2000 or 2001,” Bien said in an interview. “The military would tell you that they get a big bang for their buck. . .” A big part of that bang is the sheer number of Drexel students involved. “We probably have had easily close to two hundred different people and organizations in those years, so we bring a big network with us,” said Bien.

And the payoff is large for the students as well. “Our students will get a thesis out of some of the work they do. They contribute to the reports we give to the government in support of the INRMP. But along with that, they'll take their research a step further and do maybe a bit more comprehensive work than what was required for the military, and they present at scientific meetings, they publish—whereas a regular contractor might not be doing these kinds of things." Nor, he said, would an ordinary contractor be expected to put in the hours the students devote to their work. "For example, this young man working with me on snakes—he probably puts in hundreds of extra hours in a month on his projects simply because he's trying to get a thesis out of it and he loves what he does. … And I learn a lot from my students, and they make me look good. The trick is having good personnel around you."

One of Bien's own specialties is the Knieskerrn's beaked-rush (*Rhynchospora knieskernii*), a federally-listed threatened plant that was practically wiped out by development, but that grows happily near and within target zones at the gunnery range. Bien and his students discovered that the plant actually thrives in areas that are periodically disturbed. Bien has written that "military operations, such as mechanical disturbance, ordnance delivery, and prescribed burning, appear to be providing the necessary disturbance regime required for maintaining established sites and colonizing newly disturbed sites."

Bien is understandably happy about Drexel's partnership with the Air National Guard. "They work with us; we just have a very good working relationship. I guess that could work in most places, as long as the military would be receptive to that type of a partnership."

"The productive partnership extends", he says, "to the FWS". Because of the Drexel group's relationship with the federal agency, "we have gone on to do studies that go beyond military requirements - like greenhouse experiments, germination experiments, survival experiments. … Again, this will help not only the military but maybe down the road will help to find out about life cycles and maybe aid in delisting a species. These are the kind of things that I'm not sure other people would be doing. That would be a very good example of the value of having a university involved."

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7. Funding Natural Resources Conservation on Military Lands

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Introduction

This chapter provides a basic overview of how DoD funds natural resources management activities, including types or classes of funding, sources of funding, it describes some aspects of implementation and general strategies for funding success.

Military land managers are always scrambling for more funds with which to conserve biodiversity. There's hardly ever enough in the budget to conduct the inventories, swat the invasive species, protect the threatened and endangered plants and animals, write, update, and implement the Integrated Natural Resource Management Plans (INRMPs), satisfy environmental management tracking and reporting systems, keep up to date with (and execute) the growing number of rules, regulations, and executive orders that govern environmental protection on military bases—and keep pace with the latest findings and discoveries in environmental science, explain all they have learned to their base commanders, civil works engineers, and trainers, and, while they're doing all this, support the military missions (Powledge 2008).

Department of Defense (DoD) funds, as administered through the military services, are the primary sources of conservation funding. Other funds can come from organizations outside the base, the largest sources being other state and federal conservation programs. Ultimately, many installations employ a strategy that cobbles together funding from numerous sources.

There is wide agreement among installation natural resources managers about two aspects of funding: 1. there isn't enough of it, and there's not likely to be enough of it in the future; and 2. there is money out there, waiting for an imaginative and resourceful manager to pursue and obtain it (Powledge 2008).

When thinking about funding, it is important to recognize near-universal, strong linkages between funding, project execution/completion, and compliance requirements. All three components address particular aspects of INRMP project and other activity funding: how projects are programmed, funded, and implemented; whether funds are distributed in a timely manner; and whether high priority "must fund" projects are scientifically credible (Gibb 2005).

Natural Resources Funding Sources

An overview of the primary funding sources and some additional external sources of funding is presented below.

Appropriated Funding

Obtaining appropriated funding for natural resources projects is the responsibility of each military service, based on policy guidance issued in DoD Instruction 4715.3. Each military service has therefore developed individual environmental funding policy based on the DoD policy.

The DoD funding policy establishes the following natural resources funding priorities for appropriated Operations and Maintenance (Funding Appropriation 3400):

- Class 0: Recurring natural and cultural resources conservation management requirements. Includes activities needed to cover the recurring administrative, personnel, and other costs associated with managing DoD's conservation program that are necessary to meet applicable compliance requirements (federal and state laws, regulations, presidential executive orders, and DoD policies) or which directly support the military mission.
- Class I: Current compliance: Includes projects and activities needed because an installation is currently out of compliance (has received an enforcement action from a duly authorized federal or state agency, or local authority); has a signed compliance agreement or has received a consent order, or has not met requirements based on applicable federal or state laws, regulations, standards, presidential executive orders, or DoD policies, and/or are immediate and essential to maintain operational integrity or sustain readiness of the military mission. "Class I" also includes projects and activities needed that are not currently out of compliance (deadlines or requirements have been established by applicable laws, regulations, standards, DoD policies, or presidential executive orders, but deadlines have not passed or requirements are not in force) but shall be if projects or activities are not implemented in the current program year.
- Class II: Maintenance requirements. Includes those projects and activities needed that are not currently out of compliance (deadlines or requirements have been established by applicable laws, regulations, standards, presidential executive orders, or DoD policies) but deadlines have not passed or requirements are not in force), but shall be out of compliance if projects or activities are not implemented in time to meet an established deadline beyond the current program year.
- Class III: Enhancement or actions beyond compliance. Includes those projects and activities that enhance conservation resources or the integrity of

the installation mission, or are needed to address overall environmental goals and objectives, but are not specifically required under regulation or executive order and are not of an immediate nature. An example of a Class III conservation project that addresses important conservation and outdoor recreation goals but is not required under service regulations or federal law is the development of “Watchable Wildlife” sites and sometimes associated bird checklists to foster public recreation related to conservation.

Non-appropriated funding

In addition to appropriated funding, several other sources exist for funding natural resources projects on military lands. Among those are the revenues derived from the outleasing of agricultural lands, the sale of commercial forestry products, and the sale of hunting and fishing permits. The procedure for the collection, expenditure and accounting of these funds is provided in DoD Instruction 4715.3, which reinforces legal mandates for each funding source. That policy conforms to the unique legal requirements for each of the funding sources.

- Agricultural leases: Title 10, Section 2667(d) prescribes procedures for agricultural leases, which are also delineated in the individual service’s natural resources directives (https://uscode.house.gov/view.xhtml?req=(title:10%20section:2667%20edition:prelim).

- Commercial forestry programs: A special feature of this program is the DoD Forestry Reserve Account, which serves as an emergency holding account to ensure the self-supporting DoD forestry program remains solvent in times of low revenue. The Army serves as the DoD executive agency for this account, as specified in the DoD’s Financial Management Regulation (DODFMR 7000.14-R Volume 11A, Chapter 16). https://comptroller.defense.gov/Portals/45/documents/fmr/archive/11aarch/11a16f.pdf. Specific policy and guidance for the management of each service’s forestry account is contained in the individual service’s natural resources directives.

- Hunting and fishing fees: The authority for the collection of these fees derives from the Sikes Act (https://www.fws.gov/endangered/esa-library/pdf/2004SikesAct%20NMFWA.pdf). As with the other reimbursable accounts, specific policy and guidance for the management of each service’s hunting and fishing fee accounts is contained in the individual service’s natural resources directives.
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Other Funding Sources

Other funding sources are available to military natural resources managers, including research grants, cooperative partnerships with other government agencies, and cooperative agreements with nongovernmental organizations. The Sikes Act grants authority for the DoD to enter into cooperative agreements with nongovernmental organizations. One good source of information is the "DoD Natural Resources Funding Manual" (USAEC 2009). The manual provides descriptions and links to key grant and partnership opportunities and programs from federal, non-federal and state sources. For example, the National Fish and Wildlife Foundation builds partnerships between leading U.S. corporations and federal agencies, nonprofits and individuals who drive conservation efforts across the United States. Funds for species conservation or habitat restoration on installations may be available through state wildlife or natural resources agencies. DoD and military service FWS liaisons and state and regional FWS staff can help installations find sources of additional funding for base biodiversity conservation projects. There is a wide variety of mostly private and state funding sources to help support installation game and fish objectives.

Inventories of installation biological resources often reveal hotspots of diversity and rarity at various ecological scales (see Chapters 1, 2 and 8). These inventories and other projects attract scientific researchers eager to access military installations to conduct research, apply and test new approaches, and address knowledge gaps. Academic researchers often bring their own funding to the table, and work with installation managers to address questions that are of mutual interest.

Private conservation organizations, such as The Nature Conservancy, may not be able to bring money to the table, but they may be willing to provide in-kind assistance for projects considered mutually beneficial. Several notable grant sources that focus on military lands are described below:

DoD Legacy Program (https://www.denix.osd.mil/legacy/home/)

In 1990, Congress passed legislation establishing the Legacy Resource Management Program to provide financial assistance to the DoD for installation-specific efforts to preserve our natural and cultural heritage. In 1996, the Legacy Resource Management Program was significantly amended by the National Defense Authorization Act, Public Law 104-201, Section 2694 of title 10 to focus on DoD-wide national and regional projects. The program assists DoD in protecting and enhancing resources while enabling military readiness. A Legacy project may involve regional ecosystem management initiatives, habitat preservation efforts, archaeological investigations, invasive species control, Native American consultations, and/or monitoring and predicting migratory patterns of birds and animals, and other projects.

Three principles guide the Legacy program: stewardship, leadership, and partnership.

Stewardship initiatives assist DoD in safeguarding its irreplaceable resources for future generations. By embracing a leadership role as part of the program, the Department serves as a model for respectful use of natural and cultural resources. Through partnerships, the program strives to access the knowledge and talents of individuals outside of DoD.

Peak funding levels approached $50 million in the late 1990s, and annual funding is currently less than $3 million. When originally established in Fiscal Year 1991, the Legacy Program provided funding for specific projects on individual installations. For some years now, Legacy funding has focused on demonstration projects that have broad regional, military service, or DoD-wide applicability that could benefit multiple installations or sensitive natural or cultural resources.

The Strategic Environmental Research and Development Program (SERDP) (http://www.serdp.org/Funding)

The SERDP is DoD's environmental science and technology program, planned and executed in partnership with the Department of Energy and the Environmental Protection Agency, with participation by numerous other federal and non-federal organizations. It addresses the highest priority issues confronting the military services. Currently funded at about $60 million per year, this program focuses on applying innovative technologies and approaches to support long-term sustainability of DoD's testing and training ranges while working to significantly reduce current and future environmental liabilities.

Environmental Security Technology Certification Program (ESTCP) (http://www.estcp.org)

The ESTCP goal is to demonstrate and validate promising, innovative technologies that target the most urgent environmental needs of the DoD. The program is currently funded at about $40 million per year. These technologies provide a return on investment through cost savings and improved efficiency. The current cost of environmental remediation and regulatory compliance in the Department is significant. Innovative technology offers the opportunity to reduce costs and environmental risks. ESTCP offers funding in the following four focus areas: Environmental Restoration, Munitions Management, Sustainable Infrastructure (including natural resources/training infrastructure), and Weapons Systems and Platforms.

Partnership Funding

There are numerous programs that provide funding through partnership agreements. The Readiness and Environmental Protection Integration (REPI) Program, Army

Compatible Use Buffer Program (ACUB) and Sentinel Landscapes Program, which provide funding to manage sources of encroachment on military lands outside installation boundaries, are discussed in Chapter 6, “Partnerships to Achieve Conservation Goals and Sustain Training.”

The REPI program provides the lion’s share of partnership funding benefitting installations through encroachment management (Figure 7.1). For example, from fiscal year (FY) 2012 through FY 2019, over $141 million in DoD funds, $223 million in Department of Agriculture (USDA) funds, $41 million in Department of the Interior (DOI) funds, $169 million in state funds, $15 million in local funds, and $80 million in private funds have supported projects across seven sentinel landscapes under the Sentinel Landscapes Partnership (see Chapter 6 for more details).

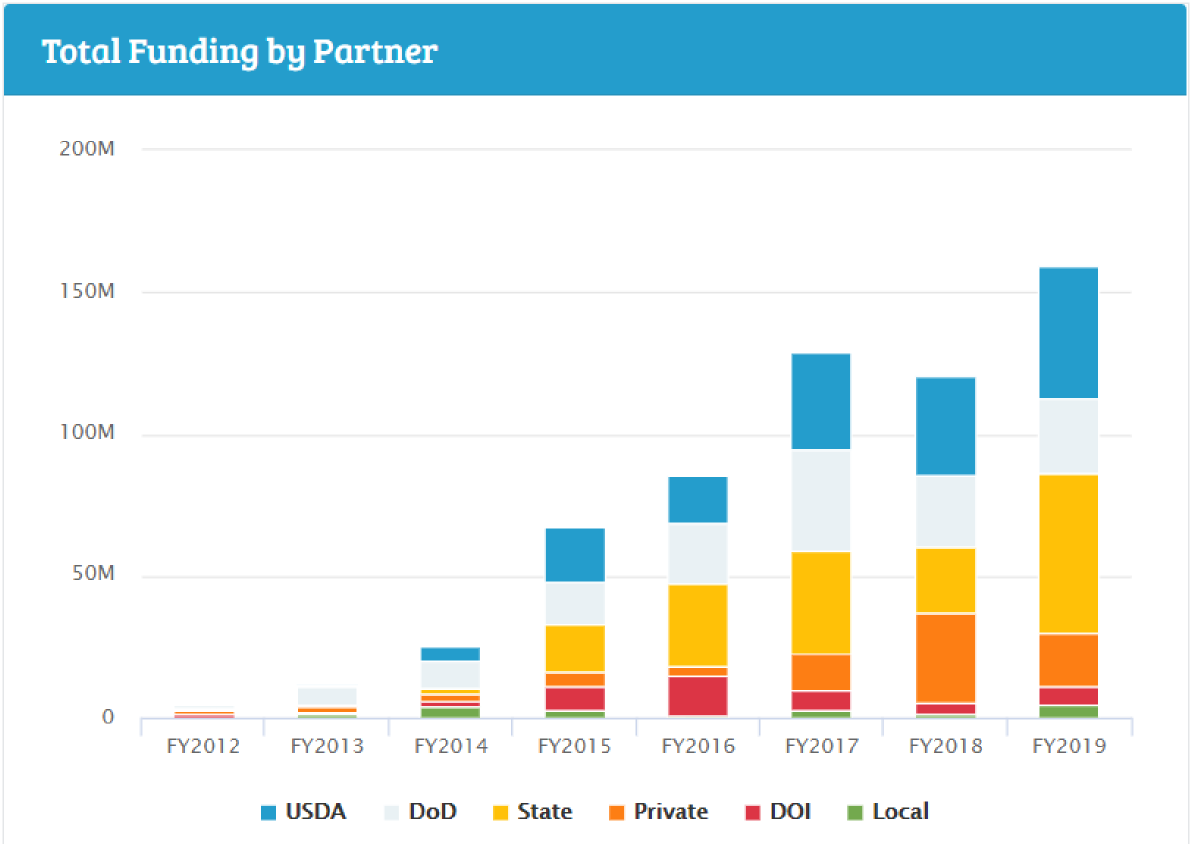

Figure 7.1. Sentinel Landscapes funding by partner by year (millions of dollars), FY12 to FY19 (source: The Sentinel Landscapes Partnership https://sentinellandscapes.org/).

Staffing Options

There are three primary avenues for staffing installation programs with available funding: in-house installation staff (GS or state employees), Intergovernmental Personnel Act (IPA) staffing, and staffing support provided by contractors and cooperators.

The Intergovernmental Personnel Act (IPA) Mobility Program (5 USC Sections 3371 through 3375) provides for assignments to or from state and local governments, institutions of higher education, Indian tribal governments and other eligible organizations that are intended to facilitate cooperation between the federal government and the non-federal entity through the temporary assignment of skilled personnel. “Other” eligible organizations include: a national, regional, statewide, area-wide, or metropolitan organization representing member state or local governments; an association of state or local public officials; a nonprofit organization that offers, as one of its principal functions, professional advisory, research, educational, or development services, or related services, to governments or universities concerned with public management; or a federally funded research and development center. These assignments allow civilian employees of federal agencies to serve with eligible non-federal organizations for a limited period without loss of employee rights and benefits. Assignment agreements can be made for up to two years, and may be intermittent, part-time, or full-time. The agency head, or his or her designee, may extend an assignment for an additional two years when the extension will be to the benefit of both organizations. Cost-sharing arrangements for mobility assignments are negotiated between the participating organizations. The federal agency may agree to pay all, some, or none of the costs associated with an assignment. Each assignment should be made for purposes that are of mutual concern and benefit to the federal agency and to the non-federal organization and that it is for sound public purposes.

At installations, there are varying opportunities to use volunteers to support natural resources management projects. A handful of installations may achieve measurable gains by using volunteers, but the primary benefit of those programs is their value in education and outreach within the installation and with surrounding communities.

Funding Implementation - Contracts and Agreements

INRMPs are implemented most through a combination of DoD/state military staffing and support provided by others (see Chapter 5 “The Integrated Natural Resources Management Plan: Foundations and Key Topics” for a discussion of staffing). Fiscal and other considerations related to implementation using contracts vs. cooperative agreements are described below.

Contracts

Federal contracts are governed by a strict set of terms and conditions, including clauses from the Federal Acquisition Regulation (FAR) and agency-specific FAR supplements. The FAR outlines the policies, requirements, exceptions, practices, and procedures to plan, form, and administer federal contracts.

Contracts are much less flexible than cooperative agreements, and poorly-written contracts and specifications/scopes of work can result in deliverables that are substandard or don’t meet the government’s needs. Modifying contracts can result in higher costs to the government and delays in delivery.

A firm fixed price type contract is the most common and preferred type of contract. This type of contract allows the cost for a given acquisition or deliverable to be determined up front—the contractor is then required to meet the contract requirements and deliverables. Fixed-price contracts place the onus on the contractor to deliver. Performance risk is lower for the agency under a firm fixed-price contract, while cost-reimbursable contracts place a higher cost risk on the agency/installation. The inverse is true for contractors on these two broad contract types.

The contractor assumes some risk under a firm fixed-price contract, but also can walk away with more profit if they are able to deliver under their projected costs. Sometimes, the agency (i.e., buyer) and the contractor (i.e., seller) will negotiate aspects of fixed price and cost-reimbursement within the contract so that the risk is spread between the two parties.

Cooperative Agreements

A cooperative agreement (CA) refers to a legal instrument used to enter the same kind of relationship as a grant, except that substantial involvement is expected between DoD and the recipient when carrying out the activity contemplated by the CA. Cooperative agreements are generally governed by Uniform Administrative Requirements, Cost Principles, and Audit Requirements for Federal Awards (aka Uniform Guidance – 2 CFR § 200). The primary authority for using cooperative agreements for natural resources support is the Sikes Act Improvement Act (16 U.S.C. § 670(c) (1). Under the Sikes Act, a project should provide for the maintenance and improvement of natural resources on base (and off-base if the project addresses restrictions related to military activities but requires a higher level of review). Support for projects can encompass all aspects of natural resources planning, implementation, management, and research, such as INRMP planning support, rangeland or watershed management, species or habitat management, wildlife management, forestry, and other activities. Using cooperative agreements with universities and other entities is discussed further in Chapter 6 “Partnerships to Achieve Conservation Goals and Sustain Training.”

One important avenue for cooperative agreements supporting DoD needs is the Cooperative Ecosystem Studies Units (CESU) National Network. The CESU Network is a national consortium of federal agencies, tribes, academic institutions, state and local governments, nongovernmental conservation organizations, and other partners working together to support informed public trust resource stewardship. The Network includes more than 470 non-federal partners and 16 federal agencies across seventeen CESUs representing biogeographic regions encompassing all 50 states, the District of Columbia, and U.S. insular areas. Seventeen CESU units provide research, technical assistance, and education to federal land management, environmental, and research agencies and their partners (Figure 7.2).

The CESU partners serve the biological, physical, social, cultural, and engineering disciplines needed to address natural and cultural resource management issues at multiple scales and in an ecosystem context. The multi-disciplinary structure of CESUs makes them well-suited to address federal agency needs for sustainability science. CESUs function as "virtual" organizations, linking federal agencies and institutions to increase access to expertise and facilities. Each CESU is composed of federal agencies, a host university, and partner institutions. DoD has at least one Military Service or U.S. Army Corps of Engineers representative in each of the 17 CESU regions. These representatives are DoD's point(s) of contact in each region and serve as the "hub of communications" on CESU matters.

The CESU arrangement is also extremely cost effective for DoD. The current negotiated CESU overhead rate charged by cooperators is only 17.5%, well below the level of overhead that would be charged by the same universities (up to about 60%) or other cooperators (typically much more than 60%) for both non-research and research activities. This enables much more to be achieved for a fixed funding amount.

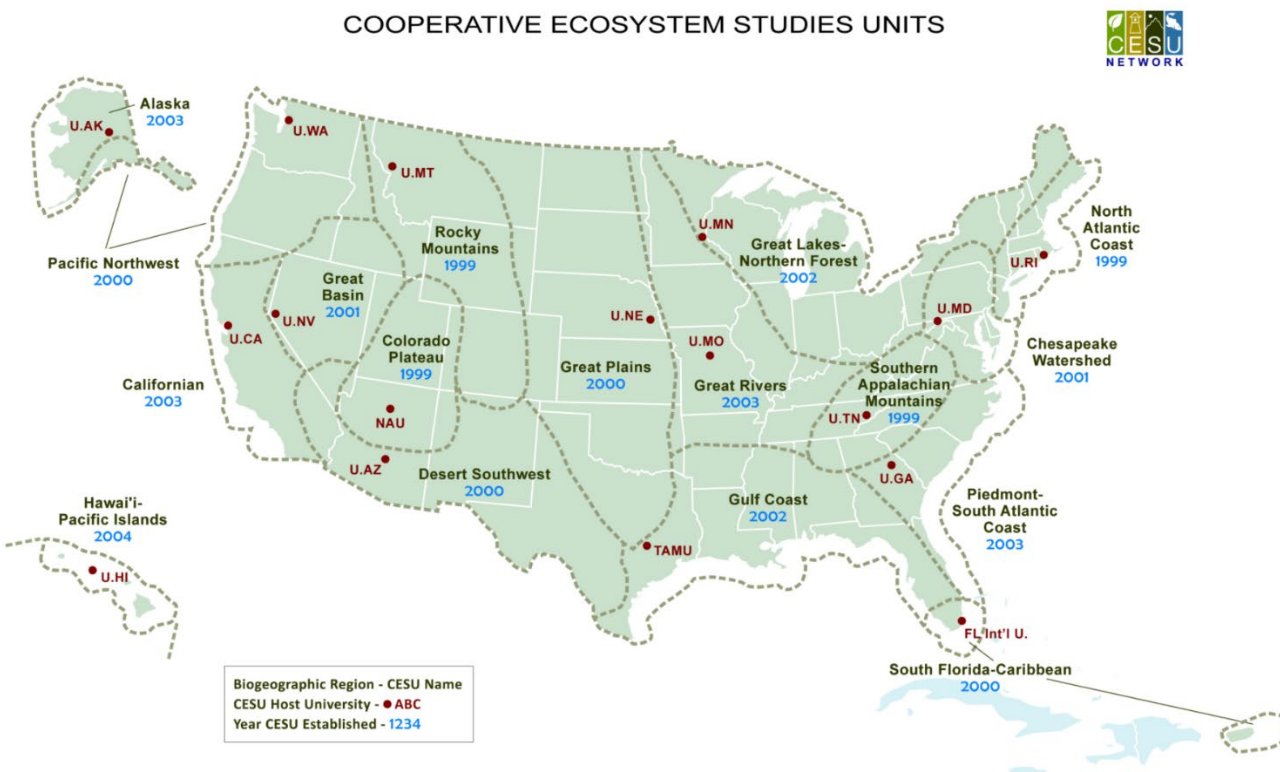

Figure 7.2. Map of Cooperative Ecosystem Studies Units

Strategies for Funding Success

There is no recipe to ensure funding will meet an installation's needs and desires. Key elements of funding success seem to hinge on exploring a diversity of funding sources, being innovative, developing partnerships that optimize access to different funding sources, and creating logical and reasonable linkages between biodiversity conservation initiatives and training sustainability on the installation and "beyond the fenceline.” The strategies presented below are adapted from Rambo (2008), based on his experience as a long-time natural resources manager at Naval Air Station (NAS) Patuxent River.

- Be completely open to any help you can get, traditional or not. This may include the use of volunteers, interns, temporary hires, partnerships, etc. Actively search out opportunities for such help. At NAS Patuxent River we have successfully used Boy Scouts and other civilian volunteers for on-base projects. On-base military members ordered by the federal court to community service is used in our invasive species control/eradication program.
- Constantly seek external funding sources. Examples include using mitigation funds for on-base construction projects (e.g., wetlands mitigation, biological surveys, etc.). Local colleges and universities are often interested in pursuing on-base natural resources research or applied work projects at reasonable cost.
- Actively pursue cooperative agreements. These agreements support project needs at a fraction of the cost of contracts.
- Seek out partnership opportunities that leverage available resources.
- Always be willing to share your data. Natural resources data should be made available to interested agencies, researchers and non-governmental organizations. For example, all biological inventory data should be shared with NatureServe Network Programs that operate in each U.S. state for inclusion in its local data management system. This data is rolled up into the NatureServe Network Biodiversity Location Database allowing accurate, range-wide assessments of species and ecosystems. This willingness to share data can lead to new opportunities for partnerships and help build the body of science surrounding resources of interest.
- Integrate/coordinate your INRMP with as many other plans as possible (e.g., base master plan, training/testing/operations plans, etc.).
- Get to know your installation’s military mission and try to link everything to it.
- Be open to new natural resources management approaches that save money while enhancing biodiversity. At Naval Air Station Patuxent River, the plan to narrow utility rights-of-way for buried utilities through forested areas is an excellent example of this approach:
- Historically, 150-foot-wide fire breaks were established along rights-of-way for buried sewer, water, and electric utilities.

- Costly, ongoing maintenance was required for these corridors (mowing and other vegetation control).
- Excessively wide corridors effectively fragmented large forest blocks, reducing the size and quality of wildlife habitat, especially for migratory birds.
- The base was able to reduce the width of fire breaks from 150 to 50 feet, thus eliminating the need to mow and otherwise maintain hundreds of acres. No impact to the military mission occurred as a result of this decision, cost savings were significant, and habitat for biodiversity conservation was created or enhanced.
- Establish volunteer programs to implement projects.
- Use troop labor and equipment—it may fit in with a program of instruction or relate to meeting training requirements/mission-essential task list.

Funding Issues

Classification and funding of stewardship projects/activities[57]

Funding continues to be the weakest part of INRMP implementation and appears to be the major impediment to effective INRMP implementation. In spite of this, many installation natural resources managers are succeeding in implementing the INRMPs. Typically, it is a patchwork of projects that are undertaken. Compliance-related projects, which for natural resources are almost always driven by the Endangered Species Act (ESA) (also the Clean Water Act or other regulations), are programmed as such, approved, and funded. In her analysis of INRMP implementation across the military services, Gibb (2005) concluded that these ESA-driven projects and activities do reach the intended programs and are used for the intended purposes. This, however, is not the case with noncompliance-related projects, and the situation can vary markedly among installations. Services' budget systems, such as the Army's Environmental Program Requirements Module (EPRM), were designed for engineering projects with known start and end points, and they are tied to compliance with federal and state laws. Although the Sikes Act Improvement Act of 1997 requires INRMPs to be implemented, many projects are continuous or opportunistic "stewardship" in nature and are not easy to define under the strict legal compliance drivers that are applied to the military services' environmental budgeting process.

Despite the need for flexibility and fluidity for natural resources projects, including the need to support a variety of stewardship projects that are not tied to compliance,

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[57] Adapted from Gibb (2005), Best Practices for INRMP Implementation.

EPRM and other systems are tied to compliance with laws, resulting in many valid INRMP projects being screened out of the budget process. The programming and funding of INRMP projects can hit obstacles throughout the programming process. Projects may initially be appropriately classified for budgeting purposes, but as they pass through the review steps, some may be reclassified to a lower level or dropped from the process entirely. The DoD guidance for classifying projects is not consistently adhered to and, in many cases, only projects that have a legal driver or involve human safety issues are being considered as “must fund.”

A related issue is that although detailed information and justification are required on the front end of the budget requests, once budgets are funded, there is no equivalent tracking of awarded funds back to approved projects. In many cases, Gibb (2005) found that projects were budgeted, approved, and funded, but the funds were either not received or not applied to the projects for which they were intended. As a result, the same projects had to be resubmitted in subsequent budget requests. This “misuse” of the budgeting process may have since been addressed to some degree by the military services. Various measures of merit used by the military services also attempt to get at funding problems by requiring annual reporting of INRMP implementation. Gibb (2005) felt it was unclear whether measures of merit being applied reflect an accurate picture of INRMP implementation because of how projects are classified for budgeting purposes. Although INRMP implementation is required by the SAIA, many do not consider it to be a legal driver for individual INRMP projects.

The strict classifying of projects based on legal drivers that has occurred in the military services has the effect of budgets showing only class 0 or class 1 projects, and these will likely be more critical from a compliance or legal standpoint. The bias towards class 0 and class 1 projects in the budget process has the effect of reducing or eliminating the overall number of unfunded projects that will show in the annual reporting for INRMP implementation. Most influence seems to be at the installation level. Because class 2 and 3 projects fail to be funded and are frequently no longer included in budgeting, they may no longer be included in INRMPs and may be eliminated as installations prepare the INRMP updates. Gibb (2005) found several installations where the only projects included in the current INRMP were “must funds” (i.e., class 0 or 1).

Pooling funds among federal agencies

The following recommendation regarding DoD’s conservation strategy is from Li and Male (2020): “DoD needs more tools that allow pooling of funds across federal agencies to effectively manage natural resources on a landscape scale, because DoD will rarely have the resources to fund this work on its own. What do we mean by pooling? It is the ability to obligate funds from multiple agencies or U.S. Treasury accounts through single funding mechanisms (e.g., contracts, cooperative agreements, interagency agreements) without having to track and account separately for each agency's allocation.

The White House Council on Environmental Quality or the Congressionally-chartered National Fish and Wildlife Foundation already have limited authorities that could help pool funds. The Sentinel Landscapes Partnership and other initiatives have made inroads within current policy and fiscal constraints toward this end." Li and Mali argue that DoD needs much more ambitious use of those authorities or new legislative authority to establish more expansive pooling authority for DoD.

Building staff capacity in partnership with state and Federal agencies

While there are many examples of successful involvement and engagement by state and federal agencies in planning and implementation of activities that favor biodiversity conservation, more funding/capacity is needed to enable federal and state natural resources and wildlife agencies to engage more effectively in plan development (Gibb 2005, Li and Male 2020, Benton et al. 2008).

Consistency and compliance with policies and legislation are key elements of INRMPs, so effective engagement and involvement during key points such as ESA consultation, INRMP revision and partnership development is paramount. Improvements to the planning process are likely without additional capacity at FWS to fully participate in conservation planning through INRMPS and other instruments (Li and Male 2020). Gibb (2005) noted that in some instances, "[Fish and Wildlife Service] staff is clearly overextended and unable to meet many of its responsibilities".

Fifteen years later, similar observations and concerns were voiced by Li and Male (2020): "Some FWS offices appear to engage minimally or not at all in plan revisions due to inadequate staff capacity." Limited state agency engagement results in missed opportunities to implement regional partnering and other projects that might mutually benefit state Wildlife Action Plans and INRMP goals. A lack of interaction with state natural resources agencies is sometimes due to staff shortages at state agencies rather than a lack of need for ongoing state involvement (Gibb 2005).

Solutions to the above issues may involve a combination of two related elements: supplementing staffing in agency offices using DoD funds, and establishing and regularly maintaining relationships with these agencies. With respect to FWS consultations and coordination needs, although DoD has funded service and DoD-level FWS liaison positions, supplemental effort at local and regional FWS offices is still needed. There are examples of DoD funding local FWS staff to support the demands of installations with monumental consultation needs (e.g., Camp Pendleton) (Gibb 2005). Support for these types of positions is especially helpful, as staff turnover at FWS can make for inefficient and extended consultations.

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Part III. Key Topics in Conservation Management

8. Managing Landscapes and Ecosystems

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Note: Chapter (8) is composed of the introduction section below followed by 5 numbered subsections (8.1, 8.2, ...). These subsections discuss assessment of landscape and ecosystem dynamics, condition, connectivity, and climate change adaptation at different scales. Each of the subsections is followed by a “Resources” section with additional links and references of potential interest to the reader. After the last of these subsections is a “Literature Cited” section that contains all literature cited in the chapter.

Introduction: Adaptive landscape and ecosystem management

This chapter provides a background on conserving biodiversity at landscape and ecosystem scales. It covers facets of systematic assessment and planning for ecosystem representation, landscape dynamics, recovery and maintenance of ecosystem condition, and considerations of landscape connectivity. Subsection 8.5 introduces key aspects of monitoring with an emphasis on ecosystems and landscapes. Chapter 9 addresses managing for Threatened, Endangered, and At-Risk species.

Ecosystem representation

Natural resource inventories document baseline information about the type, location, quantity, and other characteristics of specific resources. Terrestrial ecosystems are commonly described using vegetation, where rooted plants on land, or in shallow water, are readily recognized. Aquatic ecosystems, such as rivers, lakes, and oceans, do not support rooted plants and are often described in terms of their physical environment, hydrology, and fish or invertebrate animals.

Ecosystem classifications describe types of ecosystems present. That is, when one encounters vegetation or a lake or stream in the field, the classification attempts to answer the question, “what is it?,” and give it a name. Ecological classifications describing terrestrial and aquatic ecosystems provide an analogous function to plant or animal taxonomies, allowing for a practical categorization and description of types. In practice, they facilitate communication and the systematic accumulation of knowledge about recurring ecological patterns and processes.

Ecosystem classifications take a variety of forms. In terrestrial environments, a focus on plant assemblages, or vegetation, is quite common (FGDC, 2008; Faber-

Langendoen et al. 2014), while others emphasize geophysical components affecting wetland hydrology or soil productivity (Brinson, 1993; Caudle et al., 2013) or some combination of the two (Comer et al. 2003, Cowardin et al. 2013). The U.S. National Vegetation Classification (USNVC) is the federal standard for describing vegetation and is often used in vegetation-based inventories. In aquatic environments, ecological classifications are much more limited, but they tend to emphasize geophysical attributes (hydrologic regime and water chemistry) in type definition (Higgins et al., 2005; Sowa et al., 2007).

Ecosystem maps then answer the question: “where is it?” They depict the location of ecosystem types in space and time. Ecosystem inventory may then combine information on the ecosystem types and locations, and then quantify aspects such as the composition and abundance, answering the question of how much is there?

Vegetation inventories primarily document the extent and pattern of vegetation types, and often form a foundation for understanding wildlife habitat, rangeland and forest productivity, and other upland and wetland natural resources on any given land area. An understanding of the vegetation types, and how they form recurring patterns on the landscape, as well as knowledge of expected plant community composition and dynamics, is critical for guiding land management decisions.

Box 8.1: Ecosystem mapping

Maps are abstract depictions of the patterns one can observe in the field. A photograph is as close a representation one will likely have for that field observation, but a map must simplify that scene and apply consistent coding to each map unit. The increasing need to collect data across diverse landscapes, scales, and ownerships has resulted in a wider application of remote sensing, Geographic Information Systems (GIS), and associated geospatial technologies for natural resource applications. Key steps in preparing or using vegetation maps include defining user requirements for thematic and spatial resolutions, use of georeferenced sample data, mapping procedures, and assessing map accuracy. Here we provide background on commonly available vegetation-based maps, some methods used in their production, and examples of how map products may be used to address inventory needs of DoD.

Thematic resolution refers to the conceptual detail of the classification unit being mapped. For example, using the USNVC, which is a multi-level classification, one might select a thematic resolution or mapping at the Macrogroup-, Group-, Alliance- or Association-level of classification, each describing an increasing degree of thematic detail. Figure 8.1 includes an example of mapping vegetation and land cover at the U.S. Air Force Academy, where vegetation types are mapped at Alliance- and Association-levels of the USNVC.

Importantly, the USNVC describes existing vegetation, with units spanning the continuum from apparently “natural” types (i.e., re-occurring plant species assemblages not apparently influenced by human actions) to “cultural” (e.g., lawns or farmlands planted and maintained by people). “Ruderal” classification units reflect vegetation falling in between, such as “old fields” that were previously converted lands and later abandoned. The plant species assembled in these areas have “no natural analog,” but neither do they require planting and maintenance.

Spatial resolution refers to the spatial detail depicted on the map. For maps generated to depict polygons, the “minimum map unit” (MMU), identifies the smallest polygon one will encounter in the map. Therefore, features that naturally occur in patches smaller than the MMU must be subsumed into adjacent or surrounding features. Aerial photographs are one primary source for producing polygon-based vegetation maps, and for local installation maps, the scale of the photos typically varies from 1:8,000 to 1:16,000, depending on the cameras used and the altitude of overflights. Aerial photography in the United States was systematically initiated in

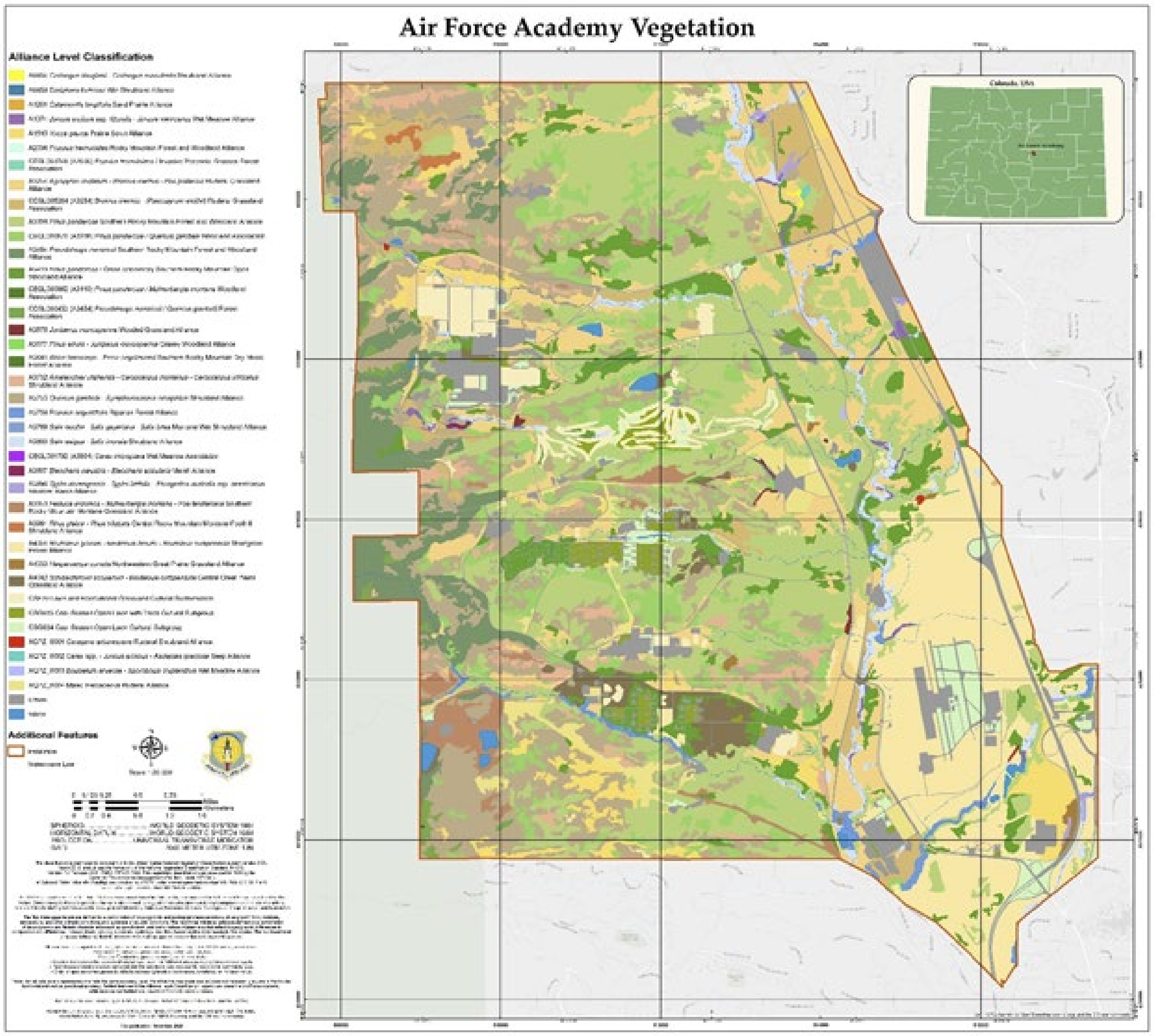

Figure 8.1. Vegetation and land-cover map for the U.S. Air Force Academy; concepts are at the Alliance and Association levels for natural and ruderal vegetation *(map produced by AFCEC/CZCA).*

the late 1930s. Detailed polygon maps might reliably depict vegetation with MMU around 0.5 acre (2,023 m^2).

Other maps are developed as rasters instead of polygons. Raster map layers are made of squares, or pixels, that depict type distributions. A common pixel size in vegetation-based mapping is 30 m. That is, each pixel represents an area on the ground of 30 m by 30 m (900 m^2) in size. That size originates with the pixel size of images taken from cameras mounted on satellites. Beginning in the early 1970s, these earth observations from space have been gathered and data resulting from those observations are increasingly available for map making. In practice, vegetation maps generated using satellite imagery should not be considered reliable at 30 m pixel resolution. In fact, users should consider clusters of 30 m pixels between 5-10 acres (20,000-40,000 m^2) in size as practical for using these types of maps.

Thematic and spatial resolutions in vegetation mapping interact primarily with the natural spatial character of a given vegetation type. Be it a 30 m pixel resolution or more detailed polygon coverage from aerial photos, vegetation types that occur as small patches and/or with an appearance that is difficult to distinguish from above will be difficult to map reliably using remote sensing. Therefore, map users need to be clear about their requirements for the vegetation maps they intend to create or use. One must match the opportunities and limitations of the map with the needs and available resources associated with the decision-making process they are intended to support. One must continually ask, “do I truly require a specific high thematic and spatial resolution, or can I make do with more coarsely scaled data?” If the decisions in need of support require more detail than available maps and mapping resources allow, field survey and documentation may be required.

For national-scale mapping, current efforts such as with LANDFIRE, produce maps at the thematic resolution of NatureServe terrestrial ecological systems for existing vegetation type. The 2020 iteration of LANDFIRE, a second existing vegetation type map depicts the USNVC Group level for natural vegetation types.

LANDFIRE applied similar methods to develop maps of potential extent called Biophysical Setting (i.e., as types likely occurred with natural disturbance processes but without intensive human use impacts) (Rollins 2009). The main differences in the modeling approach are a) current satellite imagery was not used, as it depicts current patterns of land conversion or alteration, and b) fire dispersal and spread across different landscape settings was used to simulate historical fire effects and vegetation response (Figure 8.2).

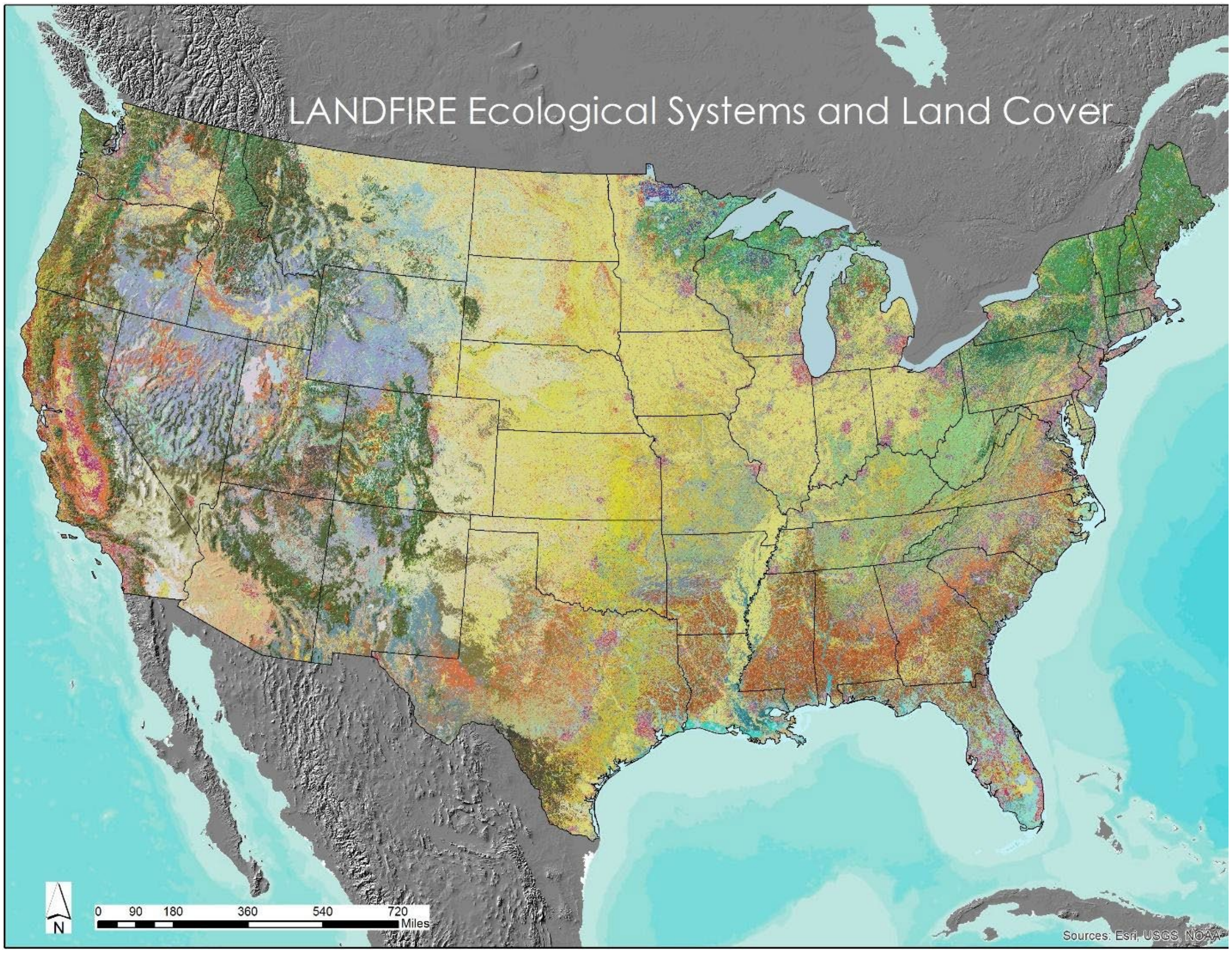

Figure 8.2. LANDFIRE map of Ecological Systems and Land Cover

Planning for landscape and ecosystem management

Planning decisions reflect resource management goals and objectives. They might stem from monitoring and evaluation of resources conditions, needs for changing land use designations, or determining appropriate resource uses.

Planning decisions typically fall into two categories: desired outcomes and allowable actions. Desired outcomes state goals and objectives for management that may be achieved within the planning time horizon. Allowable uses must identify the uses, or allocations, that are allowable, restricted, or prohibited in a given area. Management actions are the specific actions anticipated to achieve desired outcomes, including actions to maintain, restore, or improve land and water conditions. They may include specific actions or measurable criteria that will guide day-to-day activities.

Planning may encompass different geographic scales (e.g., regional vs. site specific) and timeframes (short-term vs. long-term), providing a comprehensive basis for implementing resource management actions. Planning at multiple scales may be necessary to resolve issues for a given area that is different from a plan defined for activity within the boundaries of a given DoD installation. For example, land use encroachment, invasive species, wildfire concerns, or ecosystem representation that cross jurisdictional boundaries may be assessed at broader scales, and then desired outcomes and management actions on the installation may be addressed in the context of that broader landscape.

Box 8.2: Conserving rare and special status vegetation types

The native diversity of vegetation types includes many types that are quite common and abundant across the landscape as well as those that are quite rare or considered at-risk of range-wide loss. The latter vegetation types may represent uncommon environmental conditions, such as serpentine or limestone outcroppings, where soil characteristics limit the pool of native plant species that could survive, and result in distinct plant assemblages.

In other instances, long histories of intensive land uses have resulted in the decline in extent and/or condition of the vegetation types to the point where there is significant conservation concern across their range of distribution. NatureServe and its network of state/tribal Network Programs conduct biodiversity field inventories and apply systematic criteria to determine the relative at-risk status of ecosystem and vegetation types. These criteria factor together trends in community extent, condition, and change agents to assign ranks from critically imperiled to relatively secure. In addition, the International Union for the Conservation of Nature (IUCN) has initiated efforts globally to “red list” ecosystem types for targeted conservation. Red listing identifies types that are considered “critically endangered,” “endangered,” or “vulnerable” throughout their range of distribution. Progress in this global effort includes vegetation types managed by the DoD in North America.

Planners should consult with NatureServe and Natural Heritage programs in their area to determine if there are at-risk ecosystems and vegetation types that they should be planning for their conservation.

In some cases, allowable actions may need to be more restrictive to protect sensitive ecosystem types occurring in easily disrupted environments. For example, this could be the case where surface soil disturbance could result in permanent damage or require decades for recovery. However, there are also many cases where active management—such as maintaining natural disturbance processes like wildfire—or some form of vegetation treatment are entirely appropriate to restore and maintain at-risk ecosystem types.

Landscape and ecosystem goals and objectives

Desired outcomes for landscape and ecosystems might be established at multiple scales. For example, this could include identifying areas of ecological importance that, at a regional scale, represent characteristic and at-risk ecosystem types and provide habitat for special-status species. They may also identify regional to local land use restrictions and/or treatment zones to achieve desired vegetative states and conditions. Often, implementation decisions identify the site-specific management practices, such as vegetation treatments to achieve desired vegetation structure and composition.

First, assessment could address a range of management questions regarding ecosystem types, including where is each type? Are there types considered to be endangered or vulnerable? What proportion of the type occurs on DoD lands vs. other agencies vs. private lands? How much of each type occurs within different levels of protective management, such as in parks and wilderness areas? What is the current ecological condition of the type occurring on the installation? Is there a need for actions for restoration or maintenance?

The results of these assessments could identify needs for changing current resource management on the installation. They could suggest goal statements, such as securing high-condition examples and/or some proportion of the distribution of each vegetation type within protected or compatible managed lands on or adjacent to the DoD installation. These areas could provide habitat to head off listing of species that could become listed under the Endangered Species Act. They could also serve as "reference locations" for each major vegetation type to provide context and perspective for vegetation management throughout the region over time.

Related objectives could then specify locations and/or specific areal extents by ecosystem type that should be secured in this form within some time period, such as a stated percentage secured by ecoregion, major watershed, or other geographic unit. Both desired outcomes (representing diversity) and allowable uses (under some form of compatible management regime) are captured in this type of goal and objective statement.

Resources

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Open Standards for the Practice of Conservation

8.1. Understanding landscape and ecosystem dynamics

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Introduction

Not so many years ago, most scientists and natural resource managers categorized major natural disturbances as catastrophic events disruptive of otherwise stable states (Clark 1991). Hurricanes, tsunamis, floods, and especially wildfires were thought to produce deviations from otherwise stable ecological systems—interruptions in the progression of species changes and ecosystems toward a climax, or a steady state (Cowles 1899, Clements 1937, Platt and Connell 2003).

These views have changed. Natural disturbances are now recognized as integral and necessary components of ecosystems worldwide. Resource managers who once considered disturbances as deviations from orderly succession now view them as a natural part of ecosystems. Restoration and management actions are planned to include natural disturbances.

For most ecosystems, a self-sustaining “equilibrium” or “climax” state does not occur. Instead, species are recognized as continually responding to changes in environments and to natural disturbances (Nicholson et al. 2002, Platt and Connell 2003). That is not to say that ecosystems cannot be recognized and classified into recurring units, but that ecological classifications increasingly acknowledge the role of natural disturbance in defining the unit (Comer et al. 2003). For example, we now know that fires favor species that survive fires in some life cycle stages and that are adapted for post-fire environments (Platt 1999). Different species thus may be favored under different fire regimes (e.g., Keeley and Zedler 1978, Glitzenstein et al. 1995), and recurring patterns of vegetation can reflect natural dynamics (Leitner et al. 1991). Moreover, some species may engineer disturbance, such as fires, through modification of characteristics and effects of fires, and thus these species influence species composition of ecosystems (Platt 1999). This more current thinking emphasizes the non-equilibrium nature of ecological systems—as a result of ongoing, recurrent, environmental changes, among which are disturbances. These changes are as much a part of biological life on military installations as they are anywhere else.

Disturbance regimes

Ecological disturbances, current thinking holds, are relatively discrete events that affect landscapes in disruptive ways. Each disturbance type and even successive disturbances of the same type are unlikely to affect natural landscapes in precisely the same ways. Thus, it is difficult to predict the exact effects of the next disturbance in any natural landscape. Nonetheless, if similar or different types of disturbances recur with some regularity, then a disturbance regime is produced that may generate predictable consequences. These disturbance regimes often are characterized by the type of disturbance, frequency/return interval, and seasonal timing. Examples could be the intensity of windstorms, duration of floods, or frequency and season of fires. The characteristics of disturbances often vary within landscapes and recurring vegetation types, and may interact with landscape components, like natural “fire breaks,” as well as prior disturbances, to influence the size of the area affected, as well as the intensity, patchiness, and local effects on the animal and plant life and the environment.

Disturbances often are numerous and occur at many different spatial scales. Here, we contrast disturbances at the largest and smallest scales. Disturbances at smaller scales tend not to affect landscapes or even entire patches of vegetation. These disturbances may be important, however, as a result of their combined effects over space and time. Burrowing animals can alter soil structure, for example, and over time change the substrate in ecosystems, as well as directly affect the plant communities where they occur. Likewise, lightning strikes affect individual trees, but consequently influence whole guilds of cavity-nesting birds or wood-consuming insects and their associated predators and parasites. In forested land, a fallen tree can open a gap in the canopy that might produce a sunlit microclimate on the ground below—and this could favor the growth of understory species.

At the other end of the disturbance scale are large-scale disturbances such as large wildfires, hurricanes, and volcanic eruptions. Large-scale disturbances are those that affect entire landscapes and their component ecosystems (Pickett and White 1985). Some examples include disturbances created by fire, wind, ice, and flooding. Invasive species can generate large-scale disturbances. For example, invasive grasses that bring fine fuel into the system may change an ecosystem’s fire frequency (Brown and Lomolino, 1998) or intensity (Platt and Gottschalk 1991). Invasives can also cause profound disturbance to soil—and the biodiversity it harbors—as can pollution, changes in land use, and climate change (Wall et al. in Soulé and Orians 2001).

Any of these large or small-scale disturbances can be as likely to happen on a military base as elsewhere. Numerous types of disturbances occur on military lands.

Those introduced by humans are primarily related to land management—forestry, grazing, use of prescribed fire—and military maneuvers.

Variability in ecosystem dynamics

Natural disturbances vary in duration, scale, intensity, spatial pattern, and return interval in any landscape. Thus, disturbances occurring at different times and different places produce different effects on ecosystems at a landscape scale. An understanding of this is valuable for the military natural resource manager. For example, fires can be patchy and of differing intensities. Not all individuals of a species are affected in the same way by a single fire. Burning at different times of a year may affect species differently. Depending on the time between burns, some species may be able to complete their life cycles or reproduce before the next event. Survivors may be present in some, but not all, areas affected by a disturbance, and the environment may be changed in different ways in different parts of the area affected by a large-scale disturbance. Thus, diversity and heterogeneity at the landscape level are often enhanced by natural large-scale disturbances (Watt 1947, Bratton 1976, Connell 1978, Beatty 1984, Collins and Pickett 1982, Pickett and White 1985, Foster et al. 1998, Platt and Connell 2003).

Temporal heterogeneity of disturbances may be predictable or unpredictable (Platt and Connell 2003). If it is predictable, it can thus favor certain types of species. For example, large lightning-initiated fires in the southeastern U.S. tend to occur at certain times of the year and even under certain global weather patterns (Beckage et al. 2003, Slocum et al. 2007). This may favor the growth and survival of some plant species. For example, wiregrass, Aristida beyrichiana (Peet 1993, Kesler et al. 2003) is recognized to flower primarily after growing season fires (Outcalt 1994, Mulligan et al. 2002). In some cases, species may be uncommon because they thrive under certain disturbance regimes that occur rarely, but such species have mechanisms to survive the intervals between successive disturbances (e.g., Sheridan et al. 1997, Schuyler 1999, Norden and Kirkman 2004).

Ecological disturbances can also be categorized in other ways. Exogenous disturbances are external to the communities, ecosystems, or landscapes influenced by those disturbances. Most large-scale disturbances fall into this category. Endogenous or biotic disturbances are internal to the ecosystem affected. Many smaller-scale disturbances fall into this category. Both exogenous and endogenous natural disturbances can be repetitive (recurrent fires or even volcanic eruptions; beaver dams on streams) or de novo (new volcanic eruptions; an invasion of a new species that re-engineers the ecosystem). Human disturbances can be considered as either exogenous (global climate change) or endogenous (clear-cutting forests), but typically are de novo in nature. On military installations, disturbances caused by the military mission are examples of exogenous events. In summary, the role of disturbances (large- and small-scale, exogenous and endogenous; repetitive and as random rare events) is pervasive and of primary importance in natural landscapes.

Conceptual models can be a useful tool for documenting current knowledge of disturbance regimes (Box 8.3). They enable users to state current assumptions about ecosystem dynamics and to consider how changes in certain states or transitions between states may affect conditions on the ground.

Box 8.3: Conceptual ecological models to understand ecosystem dynamics

Conceptual ecological models provide a means to describe how landscape and ecosystem dynamics likely occur. They assist with simplifying what can be an overwhelmingly complex dynamic process allowing natural resource managers to better understand the causes and potential responses to the conditions they observe in the field. Depending on the need for the assessment, conceptual models for the selected resource may vary from broad (e.g., covering all montane forests in an ecoregion) to more specific (e.g., pinyon-juniper woodland) to an individual vegetation patch at a local site.

Conceptual “state-and-transition” models (STMs) can be a primary source to describe dynamics associated with landscapes and the vegetation types they support. Documented models originating with LANDFIRE biophysical settings and with NRCS ecological site descriptions are two primary sources to consider (Keane et al. 2002) especially for upland ecosystems. These models aim to provide a quantitative or qualitative characterization of natural succession and disturbance dynamics for a given type as it occurs within a given regional landscape. For LANDFIRE models, a maximum of five “boxes” (or “states”) are used, typically to describe an early-succession state, two to three mid-succession states (e.g., open canopy to closed canopy mid-successional woodland), and one late-succession state that characterize dynamics unaltered by significant human influence.

The Ecological Site Descriptions are less quantitative than LANDFIRE models, but typically include more local geophysical characteristics, successional dynamics, and responses to common natural disturbances. They also might describe the effects of grazing regimes on vegetation in an area. These models form a foundation for ecological condition assessment at project scales. They initially highlight geophysical constraints and dynamics one should anticipate in unaltered conditions. They may also include effects of common ecological stressors or management practices. The model for pinyon-juniper woodland in Figure 8.3. illustrates how common stressors or management practices might be depicted graphically.

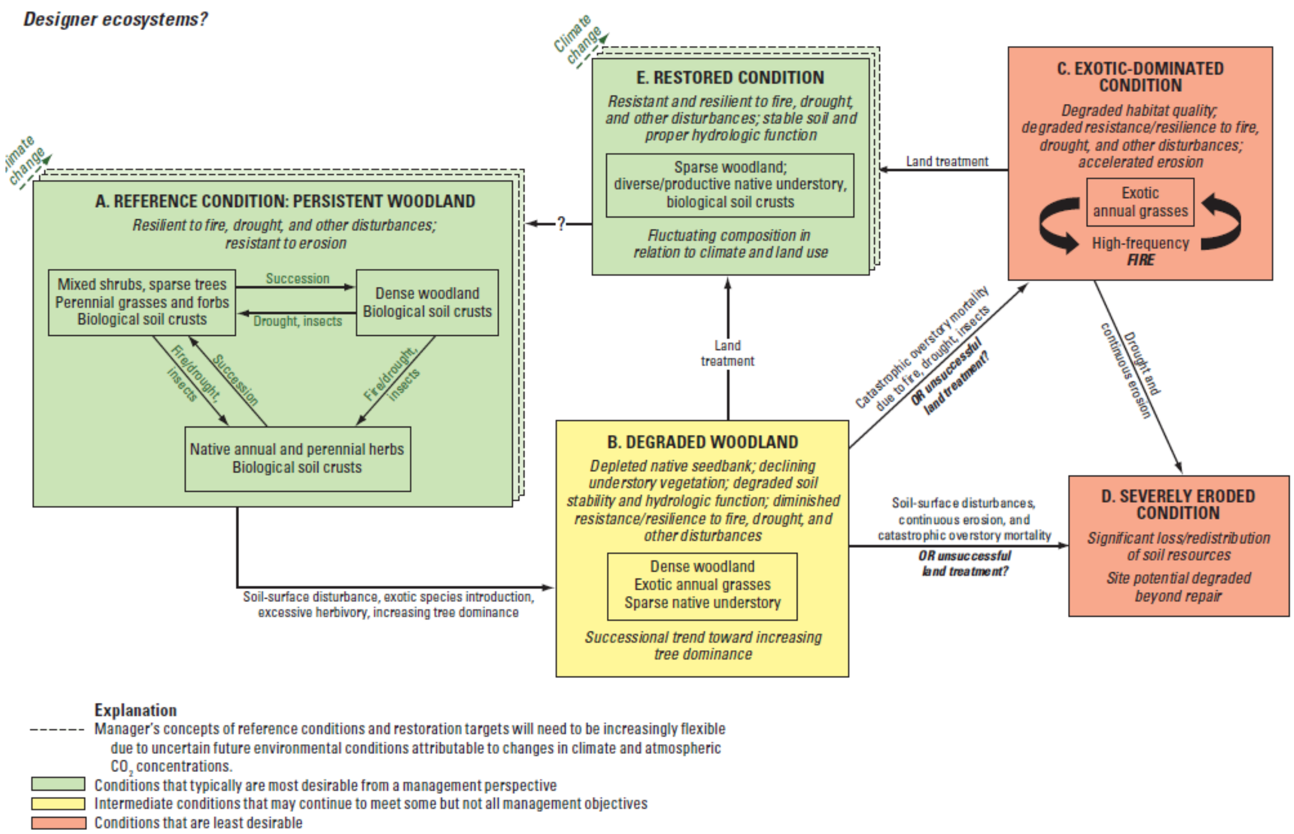

Figure 8.3. General state-and-transition model for pinyon-juniper (persistent woodland) ecosystems. Dashed boxes associated with the reference (A) and restored (D) condition indicate that managers' concepts of reference conditions and restoration targets will need to be increasingly flexible due to uncertain future environmental conditions attributable to changes in climate and atmospheric CO2 concentrations (Miller et al. 2010).

While ecological models described in Box 8.3 get at more detailed dynamics of vegetation in different landscape setting, conceptual ecological models can also be used to characterize patterns and processes taking place across more generally defined landscapes that integrate the main resources and stressors that affect management of the DoD installation. Again, the goal of this model might be two-fold. First it can identify a limited number of ecological characteristics and interactions with species and ecosystems—along with the critical causal links among them. Some of these characteristics will be especially pivotal, influencing a host of other characteristics of the target and its long-term persistence. Their identification should lead to selecting a short list of "conservation targets" that if assessed and acted upon, will represent the primary biodiversity concerns at stake for management. Second, the model, or subsets of the broader landscape model, will be used to describe key ecosystem components, their driving ecological processes, and their natural variation over time and space, and typify an exemplary, or reference, occurrence (more detail in section 5 below). Such defining characteristics of a target are the “key ecological attributes” of that target. These models provide a framework for organizing information and thinking about the target, their impacts and stressors, and anticipated management responses. Effective models help answer the question, “What are the causes that result in our current condition?”

What is ecosystem stress?

The structure and species composition of any ecosystem naturally varies over time and across regions, and experiences varying disturbances from fire, drought, wind damage, or flooding. Natural resource managers often use the concept of a natural range of variability (NRV), essentially synonymous with historical range of variability (HRV), to describe these long-term historical characteristics of ecosystems (e.g., Landres et al. 1999, Romme et al. 2012). Our knowledge of NRV is based on historical information, paleoecological studies of past conditions, research on current conditions where relatively free of human impacts, and simulation models of ecosystem dynamics (Parrish et al. 2003, Stoddard et al. 2006, Brewer and Menzel 2009). This knowledge provides important clues about the long-term ecological processes and natural disturbances that shape ecosystems, the flux and succession of species, and even the relative role of humans in shaping the systems. This knowledge provides a reference for gauging the effects of current anthropogenic stressors (Landres et al. 1999).

For these reasons, understanding NRV is an important part of ecosystem assessment. In essence, where disturbances (large- and small-scale, exogenous and endogenous; repetitive and as random rare events) fall outside of NRV, they are likely causing some degree of ecosystem stress.

There is concern that current ecological conditions are changing so rapidly that natural and historical information is no longer relevant. However, there are several ways in which NRV remains an important guide for our conceptual models of ecological integrity (Higgs 2003, Higgs and Hobbs 2010):

- First, the purpose of understanding NRV is not to lock us in the past, but to ensure that we connect the historical ecological patterns and processes to the present and future.

- Second, to suggest that we can simply take over the management of complex natural ecosystems without understanding NRV is naive and problematic.

- Third, understanding NRV will ensure that we can anticipate change and emphasize resilience in the face of future changes.

Our models and our understanding of the NRV, especially as related to disturbance, can also be informed by sites that represent reference conditions (Woodley 2010).

As described by Brooks et al. (2016), reference sites represent areas that are intact or have minimal human alteration; i.e., “reference standard” or “exemplary ecosystem occurrences.” In effect, they provide us with an understanding of the current range of conditions resulting from natural disturbance regimes. Typically, the initial approach to identifying reference sites is to rely on a combination of factors, including naturalness, apparent ecological integrity, and lack of evidence of human alteration. Naturalness and integrity are often judged by historical fidelity (connectivity in time), a full complement of native species, characteristic species dominance and productivity, presence of typical ecological processes such as fire, flooding, and windstorms, and minimal evidence of anthropogenic stressors (Woodley 2010). This information can be used to set levels of ecological integrity along a gradient from minimally disturbed conditions to severely impacted sites (Davies and Jackson 2006).

Given the extensive loss or alteration of ecosystems in many jurisdictions, current ecological conditions may only include conditions that are outside the NRV. And while management goals are not dictated by the NRV baseline in their evaluations, it is one source of information in guiding an assessment.

Not in isolation

The effects of natural disturbances cannot be considered in isolation. Disturbances may interact with one another, such that effects of an initial disturbance alter characteristics and effects of subsequent disturbances (Paine et al. 1998 Robertson and Platt 2001, Platt et al. 2002, Suding et al. 2004, Schroder et al. 2005). As a result, species may invade following sequences of disturbances, especially when de novo or rare and random disturbances are involved (Kercher and Zedler 2004, Zedler and Kercher 2004).

Natural landscapes can be greatly affected by human-caused alterations of natural disturbance regimes and by de novo anthropogenic disturbances. Altering disturbance regimes changes the environments to which species may have become adapted. Habitat fragmentation as a result of human activity is a major cause of indirect alteration of disturbance regimes, especially those of large-scale disturbances. Fires that otherwise might have swept across large regions of the southeastern U.S., for instance, are contained in much smaller areas by a fragmented landscape (Gilliam and Platt 2006). The result may be less frequent, but more intense fires that are now less dependent on global climate patterns and more dependent on fuel accumulation (Slocum et al. 2007). Similarly, floodplain communities once linked to natural flooding cycles are in altered hydrologic regimes (Sparks 1998, Sparks et al. 1990).

Human disturbances of natural ecosystems may reduce standing biomass and simplify community structure and composition (Menges and Quintana-Ascencio 2003)—or, on other occasions, they may increase biomass by interrupting normal burning cycles. Most significantly, human disturbance regimes typically deviate from historic ecological disturbance regimes and oftentimes result in radical shifts in the ecosystem, such as the introduction of exotic species (Menges and Quintana-Ascencio 2003).

Military disturbances and associated ecosystem consequences

Military lands are important ecological reserves because they often encompass large tracts of land that are protected from intensive agriculture and urban development (Boise 1997, Ripley and Lewis 1997a, 1997b, Lillie and Ripley 1998). Furthermore, some of the finest examples of fire-maintained ecosystems within the southeastern United States are found on military bases in and adjacent to artillery ranges where frequent fires are assured and unexploded ordnance provides protection from development (Peet and Allard 1993). But how do military training activities compare to the natural disturbance regimes? And how might military disturbances interact with land management activities on military bases?

Disturbances from military missions may enhance or exacerbate their effects on ecosystem components. In general, military training in terrestrial environments can be broadly categorized into two major types of disturbances—ground maneuvering (tracked and wheeled vehicles) and air-to-ground impacts. Military installations subject to usage by the U.S. Army are often subject to additional impacts from training exercises. Typically, maneuvers on Army installations involve large vehicles that can cover large areas in a single training exercise. The available land base for training has a strong influence on the intensity and frequency of usage (Demarais et al 1999) and thus on the disturbance effects.

Large-vehicle maneuvers are widely used and are consistently shown to have negative effects across ecosystems. These repeated human-induced disturbances have no natural analog. The negative effects of ground maneuvering training have been studied in California (Lathrop 1982, Prose 1985), Colorado (Milchunas et al. 1999), Georgia (Dilustro et al. 2002), Kansas (Quist et al. 2003), Washington (Severinghaus and Goran 1981), Wisconsin (Smith et al. 2002), Texas (Severinghaus et al. 1981), Manitoba (Wilson 1988), and western Europe (Vertegaal 1989). Although studies have been conducted across a variety of ecosystems (e.g. deserts, prairies, pine-oak forests, etc.) several generalizations have emerged. In particular, it is the cumulative effect of repeated military disturbances that ultimately results in reduced abundance of perennial species, overall losses of native species, increased numbers of introduced species, and increased amounts of bare and compacted soil.

While most studies have focused on effects of large vehicles, the observed results probably also include the effects of other vehicular disturbances as well (i.e. off-road vehicles) that often occur in conjunction with tracked vehicle maneuvering activities. Road-like features, including active and remnant trails and vehicle tracks, are the most prevalent disturbance features at installations with high-usage maneuvering areas (Dilustro et al 2002, Quist et al 2003). These disturbance features act to increase fragmentation of the landscape, which can in turn affect ecosystem-level processes (i.e. spread of fire, flooding, drainage, etc.).

In native grasslands where maneuvering has been examined, at least one study (in Central plains grasslands at Fort Riley Military Reservation in northwest Kansas), has shown increased bare soil, reduced total plant cover, and compositional shifts in plant communities (Quist et al 2003). Reduced cover of the perennial, matrix-forming grasses and native species, and increased cover of annual and introduced species were also associated with high-usage maneuvering training activity. Quist et al. (2003) also reported high-usage maneuvering associated with increased sediment and reduced abundance of benthic insectivores, herbivore-detritivores, and silt-intolerant aquatic species. Watersheds with high military maneuver usage also were characterized by an abundance of trophic generalists and disturbance-tolerant species. Overall, the Quist study suggests that high-usage maneuvering areas had significantly altered the nature of terrestrial and aquatic ecosystems, making them less resilient to future disturbances. To prevent significant degradation of training areas and to provide a coordinated assessment and monitoring of these impacts, the U.S. Army has implemented an Integrated Training Area Management (ITAM) program. This program emphasizes monitoring of military impacts (erosion, siltation, soil compaction, loss of native plant cover, hydrologic alterations, etc.) on training lands.

In contrast to ground maneuvering activities, air-to-ground missions are capable of mimicking natural disturbance regimes in some ecosystems. This is particularly true when active bombing and gunnery ranges exist within fire-evolved ecosystems like prairies, savannas, and some wetland types. Aerial bombing and gunnery ranges used by fighter and bomber aircraft, and artillery and mortar gunnery from ground-based weapon systems can provide the ignition sources in fire-evolved ecosystems. Some air-to-ground ranges dating back to pre-World War II contain remnant fire-maintained plant communities no longer found in the surrounding fire suppressed landscape.

An impact area on Avon Park Air Force Range in central Florida known to receive over a thousand high explosive rounds and several thousand non-explosive rounds strikes annually (Delany et al. 1999) has created a long history of frequent mission-caused wildfires that in turn have provided some of the variation inherent under a natural fire regime. Ordnance-ignited wildfires in this impact area are frequent (>1/yr), may occur year-round, and have occurred since the 1940s. As a result, the vegetation within the impact area has never been fire suppressed. Despite bomb craters created by high-explosive munitions, portions of the impact area with native vegetation support endangered birds, numerous rare plant populations, and some of the highest natural-quality examples of fire-maintained plant communities found in central Florida (Orzell 1997). Similar native species-rich plant communities, often containing enclaves of rare plants, have been recorded elsewhere in or near active air-to-ground impact areas in the southeastern United States (Peet and Allard 1993, Sorrie et al. 1997).

The influence of anthropogenic disturbance, in particular that associated with land management activities (forestry, grazing, etc.) and the military mission on ecosystem-level processes, is also pertinent when discussing disturbance effects. The interactive effects of ecological disturbance regimes and human disturbances (resulting from land management and military activities) also need to be considered, but few studies have examined these interactions. A study conducted by Dilustro et al. (2002) at Fort Benning, Georgia, in the Fall Line Sandhills ecoregion found significant interactions with other activities. In particular, forestry management practices with heavy mechanized training sites were found to favor pine dominance, and open-site, successional or fire tolerant ground cover plant species (Dilustro et al 2002).

Management implications

Management should be guided by ecological principles and strive to approximate ecologically appropriate disturbance regimes, while never neglecting the overarching need to support the military mission. In many cases, restoration of natural disturbance regimes has a positive long-term effect (Van Lear et al. 2005). Special care must be taken, of course, if there are threatened and endangered species involved. Restoration of ecosystems that have long been modified by anthropogenic activities or invasion of exotic species may not necessarily have the intended result or immediately positive consequences. For example, Varner et al. (2000) found that re-introduction of fire to a longleaf pine forest after many years of fire exclusion and organic matter buildup led to an unforeseen high mortality of large longleaf pines. In areas long degraded by fire suppression, repeated burns may be necessary (Heuberger and Putz 2003).

Another challenge for land managers is simulating natural disturbances on small parcels of land in a highly fragmented and human-dominated landscape—although one advantage of military installations may be that fragmentation and development are less of a problem than on surrounding, non-military lands. Incorporating disturbance regimes that approximate historic natural disturbances into management schemes should help to improve and maintain structure and function of the disturbance-dependent communities. Doing so, however, may be controversial and demands a great deal of planning and forethought.

Resources

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8.2. Fragmentation and connectivity

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Introduction

Ecological connectivity is the unimpeded movement of species and the flow of natural processes that sustain life on Earth (Hilty et al. 2020). Natural habitats are rapidly being lost and what remains is becoming increasingly fragmented. This has implications for the functioning of natural processes that have existed for long periods of space and time.

Connectivity in nature can be viewed at multiple spatial and temporal scales. At continental scales, annual songbird and waterfowl migration requires an interlinked chain of stopover habitats arrayed roughly north to south (Xu et al. 2020). If habitat alteration or loss and fragmentation break links in those chains, bird populations suffer. For ground- and river- dwelling species with large home ranges and/or needs for seasonal migration, connected land and waters are essential to their life cycle. Fragmenting features such as dams in rivers and intensive land uses can easily disrupt movement and population declines (Sawyer et al. 2009; Oliveira et al. 2018).

Some ecosystem dynamics, such as wildfire spreading across the landscape, or seasonal river flooding overtopping its banks, or coastal sediment transport and dune formation, can be disrupted by human-built structures that ‘fragment’ the process and alter habitat conditions (Thoms et al. 2005).

So “fragmentation” means that discontinuities appear in what were previously connected places that disrupt ecological processes requiring that connectivity.

Fragmentation decreases the size of contiguous habitat blocks and increases isolation of these patches one from another (Fisher and Lindenmeyer 2007, Kupfer et al. 2006). Although species vary greatly in their response to fragmentation it is invariably destructive to natural populations (Laurance and Bierregaard 1997, Johnson and Klemens 2005). Increased fragmentation can dramatically alter species, ecosystem, and landscape relationships and usually increases the risk of extinction (Fisher and Lindenmeyer 2007, Kupfer et al. 2006). Fragmentation results in isolated populations with decreased resiliency to changes in landscapes that are caused by a changing climate (Bennett 1999, Laurance and Bierregaard 1997).

To counteract habitat fragmentation, conservation efforts have aimed to protect natural landscapes. However, there is a limit to the area which can be set aside as formally protected, and those areas may need to have geographically fixed, legally defined boundaries. Protected landscapes within fixed boundaries also remain subject to significant external forces impacting the biodiversity within them. Furthermore, most of the world's biodiversity is found outside protected areas (Whitelaw and Eagles 2007). As areas of natural habitat are reduced in size and continuity by human activities, the degree to which the remaining fragments are functionally linked becomes increasingly important.

Consequently, one of the most frequent recommendations for protecting biodiversity is to increase connectivity and establish ecological networks that connect natural habitats (Heller and Zavaleta 2009). This conservation practice becomes even more relevant in the face of climate change (Glick et al. 2011). Under all future scenarios, with or without climate change impacts, ecological networks will play a vital role in the conservation of biodiversity through improving resilience of ecosystems and natural dispersal of species.

In part I, Understanding Conservation Biology, the importance of connectivity to conservation is discussed. Given this, there is an ever more critical need for science and practical tools to support connectivity conservation. In this section, we address how to support connectivity through DoD natural resource management. We begin by establishing an understanding of encroachment and then introduce strategies to manage encroachment and support connectivity.

Reconnecting fragmented biodiversity

The International Union for Conservation of Nature (IUCN) published guidance for creating and maintaining connectivity to benefit biodiversity (Hilty et al. 2020). This guidance should serve as a useful resource for DoD managers to gain sufficient background on ecological connectivity and then pursue practical steps to address connectivity needs of biodiversity associated with their installation.

In the IUCN guidance, two types of connectivity for species are defined that are of particular use to DoD managers. Functional connectivity describes how well genes, gametes, propagules, or individuals move through land, freshwater and seascape. Structural connectivity measures habitat permeability based on physical features and arrangements of habitat patches, disturbances and other land or water elements presumed to be important for organisms to move through their environment. Preferably, one would identify at least some key species vulnerable to effects of fragmentation and then deploy methods associated with functional connectivity. However, in the common circumstance where knowledge of species is very limited, methods associated with measuring and managing structural connectivity may be most appropriate.

An ecological corridor or connectivity zone is a clearly defined geographical space that is governed and managed over the long term in a way that is compatible with maintaining or restoring effective ecological connectivity. Each corridor or connectivity zone should have specific ecological objectives and be governed and managed to achieve connectivity outcomes.

Some examples of objectives for ecological corridors could include:

- Movement of individuals for dispersal of species for recovery across its historic range
- Genetic exchange, allowing movement over the long term among population segments for species that may be prone to genetic bottlenecks
- Migration to facilitate seasonal movement for breeding, overwintering, etc.
- Multi-generational movement, for example Monarch butterflies that migrate over several generations along a central flyway in North America
- Maintenance/restoration processes, such as hydrologic function for sediment transport or nutrient cycling, by removing dams and diversions
- Climate change adaptation, to facilitate range shifts by species from warmer to cooler zones
- Prevention of undesirable processes, such as appropriate revegetation to limit invasive species or uncontrolled wildfire spread.

See Hilty et al. (2020) for examples of methods and tools for delineating conservation corridors. While some tools are designed specifically for connecting corridors (i.e., movement from “points A and B to points C and D”), other tools provide an indication of over landscape permeability. That is, they consider (often artificial) features of the landscape that likely impeded movement for any number of species or natural processes. These sorts of tools may often be most appropriate where knowledge of individual species and populations is limited, but there is a need to consider management to increase or maintain overall ecological connectivity.

Resources

https://conservationcorridor.org/

http://www.corridordesign.org/

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8.3. Assessing ecosystem condition

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Introduction

Assessing the ecological condition of ecosystems is a key aspect of land and water management. Natural resource managers need to assess the condition of grasslands, streams, riparian areas, forests, and shorelines, and then use those results to determine if there is a need for change in management. They can then describe desired conditions and land management outputs, reconciling needs for military training. These conditions and outputs could address issues such as maintenance of riparian zones, provision of wildlife habitat, or location, type, and intensity of military use.

Like other land managers, the DoD seeks to manage lands in a manner consistent with maintaining or making progress toward achieving the fundamentals of land health; namely: (1) properly functioning physical condition of watersheds, (2) ecological processes such as hydrologic and nutrient cycling that support healthy biotic populations and communities, (3) water quality that complies with State standards and achieves agency objectives, such as meeting wildlife needs, and (4) restoration or maintenance of habitat for Federal threatened and endangered species, Federally proposed or candidate species, and other special status species. Natural resource evaluations can establish the degree to which these standards are being achieved by measuring specific ecological condition indicators relevant to each standard.

Management questions and ecosystem condition

Typically, resource management questions address some aspect of ecosystem composition, structure or function, and ecological condition assessments are designed to help answer those questions. Condition assessments result in outputs that allow military land managers to address questions such as "What are appropriate intensities of vehicle access in each management compartment? Where should we target specific types of training exercises to be compatible with maintaining wildlife habitat? What are the major stressors that need to be reduced to improve riparian functions?"

Managers also have a range of spatial scales and timeframes in which to express management questions. At the local scale, a manager may want to assess land health as part of the process of updating allowable training uses within each management compartment. Primary concerns may focus on the degree of soil compaction, local invasive plant abundance, or trends in native plant diversity, stream bank erosion, and overall biomass productivity. At the level of the installation, the need may be to report on trends in overall condition of riparian zones or grasslands relative to management or policy goals. Answers to these questions then inform resource allocation decisions associated with multiple-use management for protection of sensitive cultural resources, risk reduction from wildfire, addressing effects of altered natural disturbance regimes and invasive species, or restoring natural habitat for species of concern.

A framework for assessing ecological integrity

While there are several assessment approaches used by natural resource managers to address a range of needs, one increasingly common approach to assessing ecological condition is through measures of ecological integrity (Harwell, et al. 1999, Andreassen et al. 2001, Young and Sanzone (2002), Parrish et al. 2003, Faber-Langendoen et al. 2016, Unnasch et al. 2018). For example, the Bureau of Land Management defines ecological integrity as "the ability of ecological systems to support and maintain a community of organisms that have the species composition, diversity, and functional organization comparable to those of natural habitats within the ecoregion range or area" (from Karr and Dudley 1981). This definition embodies three components of ecosystems: composition, structure, and function. Measures of ecological integrity are now in wide use for planning, management, and monitoring purposes across multiple agencies and organizations (see examples in Carter et al. 2016, Wurtzebach and Schultz 2016, Unnasch et al. 2018). But as Pellant et al. (2018) noted, the challenge to scientists and managers is to translate this concept into terms that natural resource managers can use to assist in identifying areas where ecological processes are or are not functioning properly. Here we show how a stepwise procedure for ecological integrity assessment can help meet that challenge.

Stepwise procedure for ecological integrity assessment

This stepwise procedure supports assessment, planning, management, and ongoing monitoring of natural resources, and provides a basis for enhancing ecological resilience in the face of multiple kinds of stressors.

Specifically, the framework guides assessment of resource condition through three major steps:

- Identify the Important Resources: Determine the suite of biological and ecological resources that need to be managed. This step includes identifying the geographic (spatial) and temporal scope of the planning effort; identifying the suite of natural resources of potential concern; identifying stressors known, suspected, or anticipated to affect these resources; and selecting a subset of the unit's ecological resources on which to focus management (we'll use the term "target resources").

- Determine Indicators of Condition: Develop metrics to assess the integrity of the target resources. This step includes documenting the ecology of each target resource and identifying the key ecological attributes for each; identifying indicators for these key attributes and an ecologically expected range of variation for each indicator.
- Document the Condition of the Resources: Apply measures to determine the current integrity of the target resources. This step includes measuring indicators and determining the status of each target resource based on indicator data.

The three major steps of the framework can be detailed into 7 specific steps (Figure 8.4). In steps 1-2, the assessment effort is defined in terms of the overall area, component assessment zones or reporting areas, relevant timeframes, and target resources (e.g., ecosystem types) to be assessed.

In steps 3–5, the information is organized using conceptual models to summarize drivers and stressors, and the key ecological attributes that determine their integrity. The information guides the selection of suitable indicators and metrics to assess those key attributes. In steps 6–7, measures are gathered, synthesized, and reported. Once the assessment is complete, reported results may be applied directly to stating desired conditions for vegetation management and/or be repeated periodically within a systematic monitoring plan to track ongoing management activities. Each of these specific steps of the framework is described in detail in what follows.

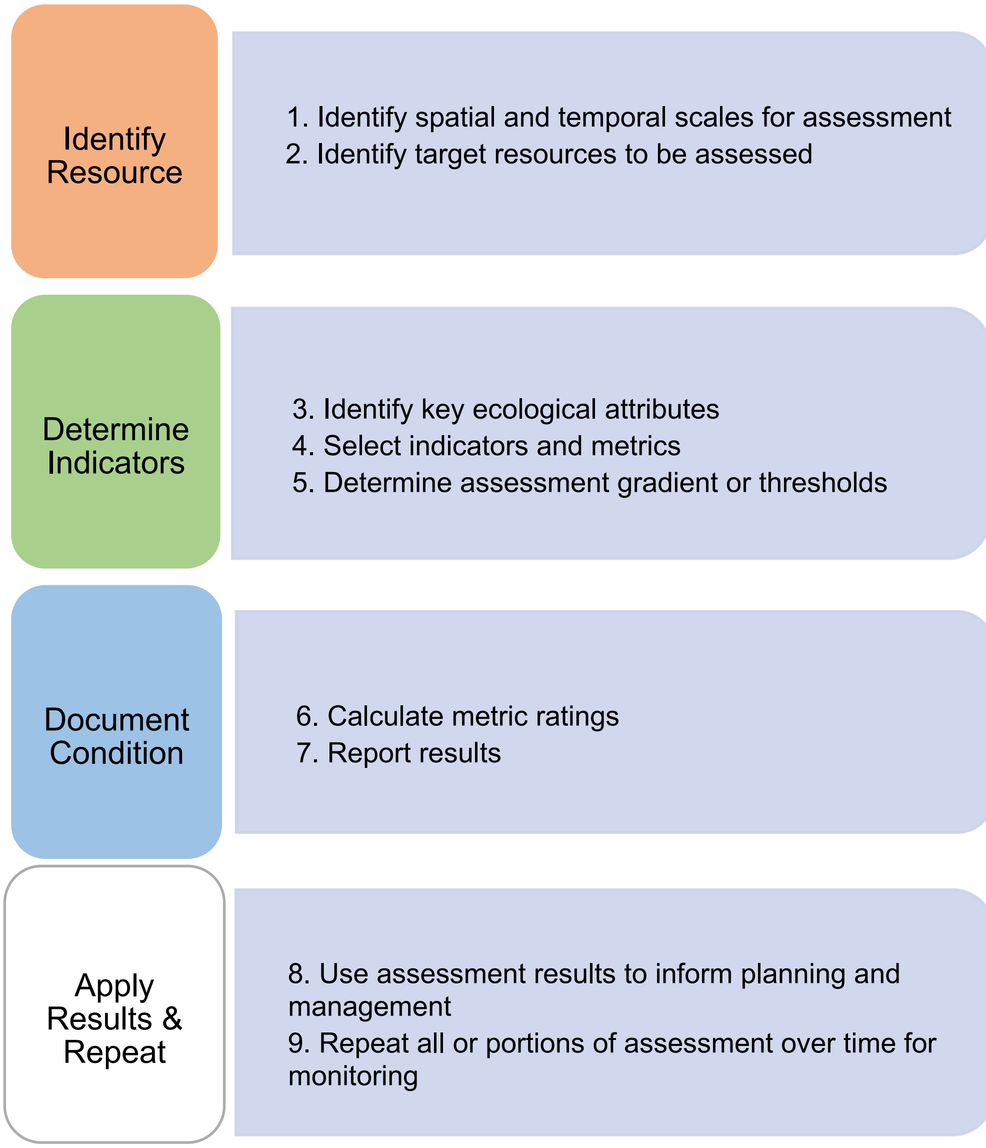

Figure 8.4. Steps for assessing ecological integrity (adapted from Mitchell et al. 2014, Faber-Langendoen et al. 2016, Carter et al. 2016, and Unnasch et al. 2018).

Identify the resources

Step 1 – Define spatial and temporal scales for assessment

Spatial scales for assessing ecological condition varies from individual sites to multiple sites across watersheds, landscapes, and regions. At small spatial scales evaluation might include assessing one or several target sites, sometimes comparing them to other similar sites. At broader spatial scales, all locations or areas of a vegetation type may be systematically compared across a managed area, watershed or region.

Temporal scales vary from a one-time assessment to monitoring over many time periods. The temporal scale also takes into consideration the timing of data collection (e.g., summer only or year-round) and the planned duration (e.g., one time or repeated).

Step 2 – Select target resources to be assessed

Broadly speaking, DoD's target natural resources might be grasslands, shrublands, forests, riparian areas, rivers, lakes, and coastal marine ecosystems, and/or habitats for selected species of concern where the agency should be able to report on their condition and trends.

As described above, ecological classifications and maps help managers better understand natural variability within and among types, and thus play an important role in helping to distinguish sites that differ across a gradient of conditions and stressors (Collins et al. 2006). Given the diversity of ecosystem types on a given DoD jurisdiction, and the different kinds of management questions associated with each, it is critical to organize existing knowledge about their location on the landscape, how they naturally function, and how land use decisions affect those functions. Descriptions of each classification unit are the practical starting point for conceptual modeling; and in many cases, are sufficient on their own. They typically include a characterization of the environmental setting, vegetation structure and composition, and sometimes include common natural disturbance regimes associated with the type. The summary description includes much about the typical environmental setting (elevation range, landforms, slopes, soils), vegetation structure and composition, including the primary species of tree shrub and herb one could expect to encounter. NatureServe's Explorer, the U.S. National Vegetation Classification, LANDFIRE biophysical settings and NRCS ecological site descriptions are all useful for accessing existing descriptions for terrestrial ecosystems that may occur on DoD installations.

Step 3 – Identify key ecological attributes

A scientifically based model facilitates the identification of the key ecological attributes (KEA) of composition, structure, and function that are most crucial for ecological integrity, and which likely respond most directly to ecological stressors. For example, with a given woodland or desert shrubland occurring across the Intermountain West, we not only need to know about the vegetation structure and composition (such as the contribution from cryptobiotic soil crusts), but we also need to describe the major types of dynamic processes (succession following wildfire) and ecological functions (such as nitrogen fixation and soil stabilization) that lead to that vegetation pattern. In another example with riparian vegetation, key attributes may include the flooding regime and the expected native composition or presence of functional groups of wetland plants or animals that provide essential structural or functional roles. Therefore, conceptual models should also include ecological drivers, such as climate regimes (e.g., drought effects) or geology (e.g., chemical extremes in soil or bedrock), in addition to more direct dynamic processes (flooding and fire regime) that influence the variation in ecological components (Parrish et al. 2003, Tierney et al. 2009).

Ecological stressors, such as groundwater pumping, or invasive species, may quickly alter the riparian system and displace native species that play important functional roles. Alteration to landscape-level natural disturbance processes such as wildfire also may be identified as common stressors because they can have cascading effects on native composition and structure, and other critical natural processes.

Determine the indicators

Step 4 – Selection of indicators and metrics

Having identified the target resource types and worked through the conceptual ecological model to identify the KEAs for which indicators are needed, the next step is to select indicators and metrics. Indicators are a measurable expression of the KEA (e.g., native species composition). Metrics are the specific forms of measurement (e.g., proportion of native to non-native species present in sample plots or transects).

Metrics specify both a) the measures needed to quantify the indicators and b) the rating scale by which those measures are informative of the integrity of the ecosystem. For example, Primary Productivity might be a commonly selected KEA for different shrubland, shrub steppe, and grasslands on DoD land. But it can be measured using a variety of methods, including a) by clipping once at the end of the season, b) sequentially during the growing season, or c) using proxy methods based on stem density or height (Pellant et al. 2018). Each of these methods uses different field measures and generates somewhat different numerical values; some may be hard to measure; others, expensive to measure. Thus, a specific metric of the indicator needs to be selected that is ecologically relevant and appropriate for meeting the manager’s needs.

Step 4.1 – Selecting metrics

When selecting metrics, the goal is to identify those that can most effectively characterize current conditions and/or be sensitive to change over time. Indicators of key ecological attributes that directly measure changes to the KEAs (e.g., hydroperiod, native species composition, coarse woody debris in forests) are referred to as “condition indicators.” In contrast, “stressor indicators” directly measure ecosystem stressors (e.g., non-native plant species abundance, number of ditches or diversions in a wetland, proximity to converted lands and roads), which are used to infer the condition or integrity of the system. Condition metrics are preferred because they are a more direct measure of ecological integrity. But stressors metrics are more commonly selected where field measurement is less feasible.

In cases where identifying a condition metric is not feasible, a stressor metric is suitable, especially where its relationship to ecological condition is well understood. For example, the expected native species composition or presence of functional groups of species are commonly identified KEAs, but the practical indicator for them might be Nonnative plant taxa because it is simpler to assess and typically is strongly correlated with native species composition. There are various metrics available to guide the application of this indicator, including percent nonnative species richness, relative cover of nonnative taxa, or the absolute cover of nonnative taxa. The presence and cover of non-native plants are then measured in the field using visual assessments in plots or transects.

Metrics can be identified using a variety of expert-driven processes and/or through data-driven calibration tests. The scientific literature should be reviewed to identify existing and tested metrics that are useful for measuring ecological integrity. For example, NatureServe's wetland assessment method was initially prototyped from a variety of existing rapid assessment and monitoring materials, particularly the California Rapid Assessment Manual (Collins et al. 2006, Stein et al. 2009) and the Ohio Rapid Assessment Manual (Mack 2001), (Faber-Langendoen et al. 2008). It was then field tested and statistically validated to achieve a rigorous set of wetland integrity metrics (Faber-Langendoen et al. 2012). State-based versions of these assessments are also available in Colorado (Lemly et al. 2015) and Washington (Rocchio et al. 2017).

Candidate metrics can be filtered with screening criteria (Andreasen et al. 2001, Tierney et al. 2009, Mitchell et al. 2014). When choosing metrics, some basic questions are often considered (Kurtz et al. 2001):

- Is the metric ecologically relevant? Conceptually relevant metrics are related to the characteristics of the ecosystem or to the stressors that affect its integrity; and can provide information that is meaningful to resource managers.
- Can the metric be feasibly implemented? The most feasible metrics can be sampled and measured using methods that are technically sound, appropriate, efficient, and inexpensive.
- Is the response variability understood? Every metric has an associated measurement error, temporal variability, and spatial variability. The best metrics will have low error and variability compared to baseline measures. In other words, good metrics have high discriminatory ability, and the signal from the metric is not lost in measurement error or environmental noise. Ideally the metric is measured across a range of sites that span the gradient of stressor

levels (DeKeyser et al. 2003) and verified to show a clear response to the stressor.

- Is the metric interpretable and useful? The best metrics provide information on ecological integrity that is meaningful to resource managers. However, they may also need to be sufficiently sensitive to detect change over time, particularly changes caused by stressors.

Step 4.2 – Three-level of effort for indicators and metrics

Depending on the purpose and design of the project, indicators of ecological integrity can be identified and assessed using three generalized levels (Brooks et al. 2004, Wardrop et al. 2013). Level 1 (Remote Assessment) relies primarily on remote sensing-based indicators. Level 2 (Rapid Field Assessment) uses relatively simple semi-quantitative or quantitative condition indicators that are readily observed in the field, often supplemented by a stressor checklist (see below). Level 3 (Intensive Field Assessment) requires detailed quantitative field measurements and may include intensive versions of some of the rapid metrics (Stein et al. 2009).

The “3-level approach” to assessments provides the flexibility to develop data for many sites that cannot readily be visited or intensively studied, permits more widespread assessment, while still allowing for detailed data at selected sites. Because the purpose is the same for all three levels of assessment—to measure the status of ecological integrity of a site—it is important that the identification of ecological attributes and the selection of metrics be coordinated. That is, if invasive or woody species encroachment are identified as key stressors, metrics that address these key issues should be identified for each level (Solek et al. 2011).

Where information is available for all three levels across multiple sites, it is desirable to calibrate the levels, to ensure that there is an increase in accuracy of the assessment as one goes from Level 1 to Level 3. For example, data from Level 2 or Level 3 metrics can be used to calibrate the Level 1 remote-sensing based indicators (Mack 2006, Mita et al. 2007, Stein et al 2009).

Other sets of indicators have been developed for local ecosystem types and that experience has allowed for generalized summaries to be established to aid in indicator selection elsewhere. See practical examples of these used by the State of Washington (Rocchio et al. 2020).

Step 5 – Establish assessment gradient and metric ratings

Assessment points and metric thresholds

Using our knowledge of a given ecosystem, we can approximate both the natural variation in a metric and the variation caused by stressors. Thus, our next step in assessing ecological integrity is to establish a range of values and one or more thresholds that distinguish expected or acceptable conditions from undesired ones that warrant further evaluation or management action. These assessment points and thresholds provide the information regarding the trajectory of a metric, whether it is moving away from the expected natural range of variation and towards an undesirable ecological threshold and possible ecosystem collapse.

A simple categorical structure can be used, such that assessment points reflect on the one end, ratings for Very High (i.e., the metric value lies well within its range of natural variability) to Low (i.e., the metric value lies well outside range of natural variability and represents significant ecological degradation, perhaps irreversible). The number of categories will depend on the degree to which various incremental changes in a metric's values correspond with changing stressor levels. Remote sensing imagery metrics, although able to generate a more continuous set of values (e.g., annual invasive plant cover), may be prone to a high error rate, so assessment points should not be too narrowly defined. Conversely, intensive field-based measures of invasive cover may be able to establish assessment points with 1–5% interval accuracy. Rapid, field-based metric ratings tend to be intermediate, and are most accurately collected using a relatively discrete set of assessment points (three to five assessment points are common).

Figure 8.5. illustrates the concept of establishing assessment points, with a desire to characterize four categories (here: A, B, C, and D) using a floristic quality index (Lopex and Fennessy 2002, Freyman et al. 2016) as the metric. It shows assessment point development (adapted from Bourdaghs 2012). Sites are assigned to groups including ("Presettlement" [A], "Minimally Impacted" [B], and "Severely Impacted" [D]). Assessment points are set at designated percentiles of the floristic quality assessment (FQA) metric for each data analysis group. Three types of assessment points are provided: 1) Desired condition (A/B), 2) Early warning (B/C), and 3) Imminent collapse (C/D).

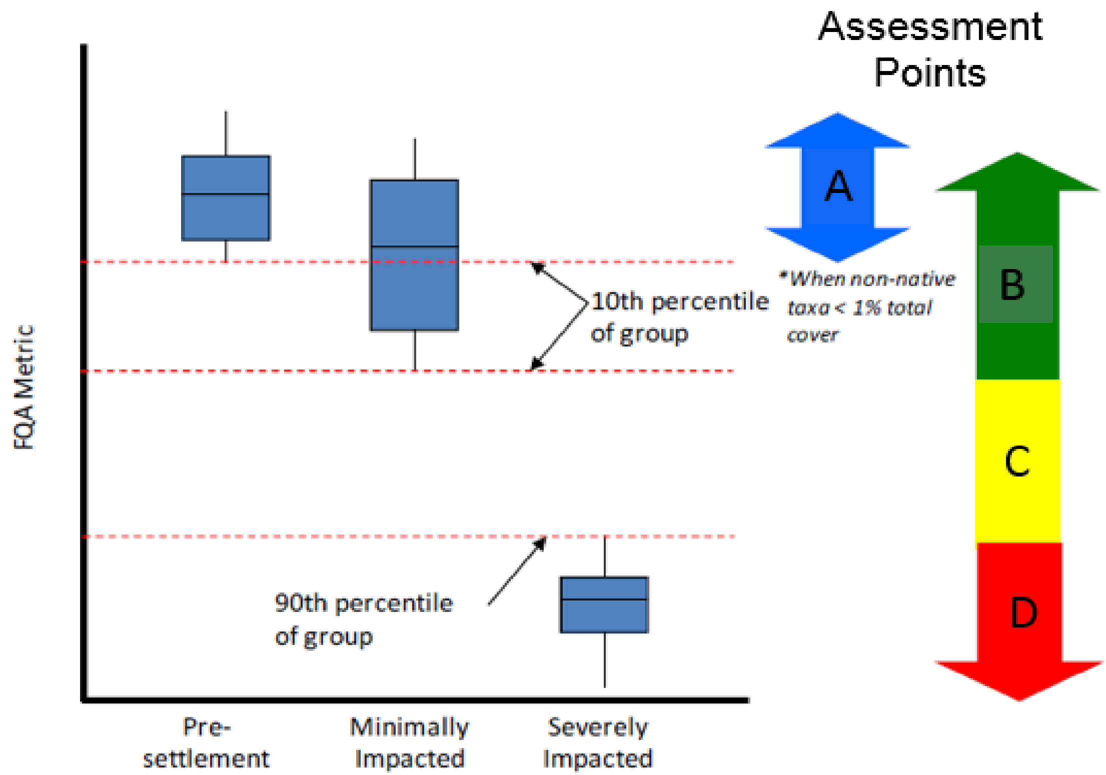

Figure 8.5. Example of establishing assessment points for one indicator of floristic quality for vegetation condition assessment (adapted from Bourdaghs 2012).

Document condition

Step 6 – Calculate metric ratings

As noted above, there are a variety of metrics suitable for use with vegetation types, management needs, and available capacities and data for measurement. At local sites, and particularly in rangelands, protocols for field measurement and subsequent summary calculations have been well-developed through the Bureau of Land Management's Assessment Inventory and Monitoring (AIM) Program and related activities with the Natural Resource Conservation Service (NRCS) and Agricultural Research Service (ARS).

Protocols are now available for several rangeland health or ecological integrity assessments (EIA). Rangeland health assessments based on ecological integrity concepts have been developed by BLM and ARS (e.g., Pellant et al. 2005, Herrick et al. 2017). Rapid field assessments based on the EIA Framework are available for a variety of wetland ecosystems, including a national wetland assessment method developed by NatureServe (Faber-Langendoen et al. 2012, 2016b, Comer et al. 2017) and various states (Colorado – Lemly and Gilligan 2015, Washington – Rocchio and Crawford 2011). Several states have both upland and wetland EIA assessments in place, including Washington (Rocchio and Crawford 2011). Field manuals and field forms are available from NatureServe and several of its Network Programs, including the Colorado Natural Heritage Programs and the Washington Natural Heritage Program.

Step 7 – Reporting on ecosystem condition

As with calculating metrics, there are a variety of suitable ways to report on metric ratings, and these vary considerably with target resource, management, and reporting needs. The goal is to ensure that the results reach the right people in a format that is accessible and useful (Mitchell et al. 2014). This could be a factsheet that highlights the overall results of assessment findings or a more detailed report that includes results of individual metrics. See for example Pellant et al. (2018) for a thorough explanation on reporting on, or describing, indicators of rangeland health (DIRH).

More generally, a common approach for summarizing ecological integrity for a local site is a scorecard that displays the ratings for each metric. This brings information together in a transparent way, allowing users to understand the status of various components of ecological integrity, and if desired, provide an overall rating. By displaying both the individual metrics, and any aggregate scores, the scorecard can provide a multi-factorial view of the site, and pinpoint areas of concern. When several metrics show low ratings, they may point to needs for intensive intervention and restorative treatments. Figure 8.6 illustrates results for wetland sites where restoration and monitoring are planned. Scoring here has been distinguished for marsh and wet meadow zones of this coastal marsh complex. The scorecard includes individual metric scores (A-D). For example, broader Landscape metric ratings were A and B, whereas metrics used to assess Vegetation mostly fell into the C and D range, primarily driven by the proportional cover of Invasive Nonnative Plant Species. However, Native Plant Species Composition scored quite differently between Marsh and Wet Meadow zones, with B for Marsh and D for Wet Meadow.

As summarized in Figure 8.6, individual metrics were aggregated to indicate B scores (B+ and B-respectively for Marsh and Wet Meadow) for Landscape Context, and C scores (C+ and C-) for Condition. The overall EIA ratings were B- for the Marsh zone and C+ for the Wet Meadow zone.

The scorecard approach is important, in that while any one metric may be failing (e.g., a D score), the scorecard provides a multi-factorial view of the system and provides some context for interpreting the significance of any individual rating. Specific management actions tend to be directed at individual metrics and/or small groups of closely related metrics. The D rating for Native Plant Species Composition and this site’s Wet Meadow zone can be explained by the dominance of reed canary grass. Targeted herbicide treatments, combined with prior actions to restore hydrologic connectivity (currently scored as C), may be the specific suggested actions. These specific metrics may be targeted for periodic re-measurement over the coming years.

Other users of the results may be more interested in aggregate scores and/or other forms of reporting that facilitate recognition of broader patterns within and among multiple restoration sites. Maps, generalized tabular summaries, and other forms of infographics, may be suitable for these types of applications.

PRIMARY FACTOR MAJOR ATTRIBUTE Metric		ROBINSON MARSH	 WET MEADOW
ECOLOGICAL INTEGRITY		B-	C+
LANDSCAPE CONTEXT	[0.3]	B+	B-
LANDSCAPE	[0.33]	A-	A-
L1. Contiguous Natural Land Cover		B	A
L2. Land Use Index		A	B
BUFFER	[0.66]	B-	B-
B1. Perimeter with Natural Buffer		A	B
B2. Width of Natural Buffer		A	A
B3. Condition of Natural Buffer		C	C
CONDITION	[0.7]	C+	C-
VEGETATION	[0.55]	C-	D
V1. Native Plant Species Cover		C-	D
V2. Invasive Nonnative Plant Species Cover		D	D
V3. Native Plant Species Composition		B	D
V4. Vegetation Structure		nr	nr
V5. Woody Regeneration [opt.]		na	na
V6. Coarse Woody Debris [opt.]		na	na
HYDROLOGY	[0.35]	B+	B-
H1. Water Source		B	B
H2. Hydroperiod		B	B
H3. Hydrologic Connectivity		B	C
SOIL	[0.1]	B+	A+
S1. Soil Condition*		B	A

Figure 8.6. Example of an ecological integrity scorecard, showing metric ratings for a wetland site. The individual metric ratings can be viewed individually or as aggregate scores, including overall rating.

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8.4. Climate change adaptation

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Introduction

While traditional natural resource management has tended to be 'retrospective'—using knowledge of past and current conditions to inform today's management actions—conservation professionals increasingly need to forecast future conditions. This forecasting is needed to determine the nature and magnitude of change likely to occur, and then translate that knowledge to current decision-making timeframes. Increasingly, it is no longer sufficient to assess "how is it doing?" and then decide what actions should be prioritized for the upcoming land use planning cycle. One must now ask "how is it changing, and by when?" and then translate that knowledge back into actions to take within one or more planning horizons.

While this re-orientation in natural resource management has become a requirement at installations with rapidly accelerating land use change, climate change now brings a globally pervasive stress on natural ecosystems. Temperature and precipitation regimes drive ecosystem productivity and natural dynamics, such as ocean temperature, seasonal streamflow, the rate of plant growth, and the frequency of natural wildfire. As the rate of climate change increases, substantial shifts in key ecological processes will cascade through local ecosystems, resulting in altered productivity, change in species composition, local extinctions, and many instances of ecological degradation or collapse (Barros et al. 2014). Therefore, in any given place, an assessment of climate change vulnerability for landscapes, ecosystems, and potentially at-risk species, is needed to forecast risk of ecological degradation or collapse. With this information in hand, managers can develop strategies for adaptation; that is management actions to reduce risk from continually changing conditions as they emerge over upcoming decades.

In their publication "Climate Adaptation for DoD Natural Resource Managers: a Guide to Incorporating Climate Considerations into Integrated Natural Resource Management Plans" Stein et al. (2019) detail a 6-step process for addressing these challenges.

These include:

1. Set context for adaptation planning
2. Assess climate vulnerabilities and risks
3. Evaluate implications for INRMP goals and objectives

4. Develop strategies and actions to reduce climate risks
5. Implement adaptation actions and projects
6. Monitor and adjust adaptation actions

Here we introduce aspects of steps 2 (vulnerability assessment) and 4 (adaptation strategies) as related to landscapes and ecosystem management by DoD.

Climate change vulnerability assessment

Climate change vulnerability is commonly defined as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes” (IPCC 2007). Vulnerability assessments tend to include a series of measurements to quantify climate change exposure, sensitivity, and adaptive capacity. In the context of conserving natural resources, these terms can be defined as:

- Exposure – is the degree to which the target resource might be subjected to the change in conditions;
- Sensitivity – the degree to which the target resource being assessed might be affected by climate exposure, including interactions of climate stress with other kinds of stress;
- Adaptive Capacity – the ability of the target resource to adjust to, and cope with, changing conditions.

Vulnerability assessments address different levels of ecological organization, such as species, local ecosystems, or landscapes. The species level is the most common focus for vulnerability assessment and consequently has received extensive attention in the scientific literature (Rowland et al. 2008, Pacifici et al. 2015). These approaches examine projected climate change where the species occurs, aspects of the genetic variation, natural history, physiology, and landscape context to assess sensitivity and adaptive capacity (Foden et al. 2018). Assessments of landscapes often produce mapped results for interpretation at regional scales. Evaluation of climate exposure may result in maps showing where climate-induced stress is indicated to be greatest, whereas examination of the potential climate-change effects on disturbance regimes or invasive species can address aspects of sensitivity (Swanston et al. 2010, Rustad et al. 2012). Adaptive capacity can be measured through examination of the heterogeneity of topography, moisture gradients, or microclimates under the assumption that more diverse landscapes provide more opportunities for organisms to find climate refugia than homogeneous ones (Hamman et al. 2015).

Assessing the vulnerability of local ecosystems provides a useful complement to both landscape and species assessments. Whereas landscape assessments indicate a high potential for regional climate-change impacts, analysis of component ecosystems aims to more directly measure how climate change will impact species assemblages, ecological processes, structure and function, and is a next logical step to identify practical adaptation strategies (Finch et al. 2012).

In one example, NatureServe developed a framework for assessing climate change vulnerability in local ecosystems and habitats. Using the framework, ecologists treated predominant upland vegetation types, such as warm desert scrub, sagebrush steppe, pinyon-juniper woodlands, and mixed conifer or aspen forests extending from low to upper montane elevations over 3.2 million km2 of Western North America.

The framework addressed climate exposure and ecosystem resilience; the latter derived from analyses of ecosystem sensitivity and adaptive capacity (Figure 8.7).

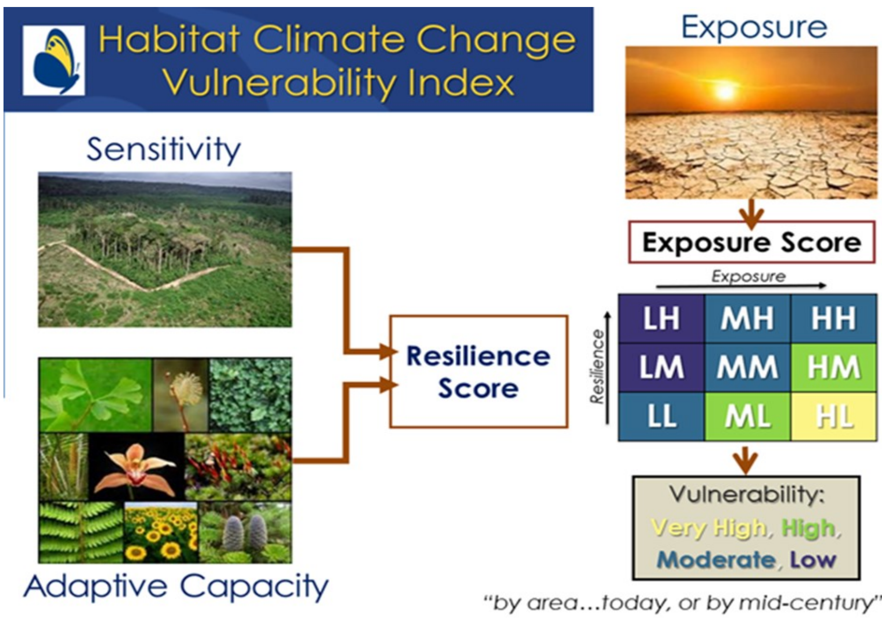

Figure 8.7. Framework for climate vulnerability assessment of ecosystems (from Comer et a; 2019)

Measures of climate change exposure used observed climate change (1981–2014) and then climate projections for the mid-21st century (2040–2069 RCP 4.5).

Measures of resilience included (under ecosystem sensitivity) landscape intactness, invasive species, fire regime alteration, and forest insect and disease risk, and (under adaptive capacity), measures for topo-climate variability, diversity within functional species groups, and vulnerability of any keystone species.

As of 2014, moderate climate change vulnerability was indicated for >50% of the area of 50 of 52 types. By the mid-21st century, all but 19 types will face high or very high vulnerability with >50% of the area scoring in these categories. Measures for resilience explain most components of vulnerability as of 2014, with most targeted vegetation scoring low in adaptive capacity measures and variably for specific sensitivity measures. Elevated climate exposure explains increases in vulnerability between the current and mid-century time periods (Comer et al. 2019).

Climate change adaptation

For DoD purposes, climate adaptation is defined as "adjustment in natural or human systems in anticipation of or response to a changing environment in a way that effectively uses beneficial opportunities or reduces negative effects" (DoDD 4715.21). More generally, adaptation actions are intended to reduce climate-related vulnerabilities or enhance resilience. Indeed, adaptation planning can be viewed as a process of iterative risk management.

Given the wide array of natural resource–related programs and activities addressed in INRMPs, it is challenging to provide guidance on specific strategies that might be appropriate to consider in any instance. For example, Swanston et al. (2016) offer one set of high-level strategies from a forestry perspective:

- Sustain fundamental ecological functions
- Reduce the impact of biological stressors
- Reduce the risk and long-term impacts of severe disturbances
- Maintain or create refugia
- Maintain and enhance species and structural diversity
- Increase ecosystem redundancy across the landscape
- Promote landscape connectivity
- Maintain and enhance genetic diversity
- Facilitate community adjustments through species transitions
- Realign ecosystems after disturbance

Results of NatureServe's analysis of western vegetation types suggest adaptation strategies that suit the character of each type, or groups of ecologically similar types. For example, warm desert shrublands and semi-desert grassland types already score in the high vulnerability range. It would be prudent for planners and managers to evaluate current landscape patterns and identify zones where they can anticipate plant invasions from neighboring vegetation (Bachelet et al. 2016). Where degraded from prior land uses, restoration of native herb diversity and nitrogen fixing taxa are also needed. Monitoring for pollinator population trends, invasive plant expansion, and shrub regeneration, are also increasingly urgent.

Further north and upslope, pinyon-juniper woodlands currently tend to score in the low-moderate range of vulnerability, but by mid-century, they score in the moderate to high range of vulnerability. Actions to maintain or restore resilience in these forests are needed. These could include protection of remaining “old growth” stands while restoring natural wildfire regimes and tree canopy densities in the surrounding areas.

Over the coming decades, as temperature and precipitation patterns change, models of wildfire regimes will need to be updated and customized to local conditions. Monitoring for invasive plant expansion, effects of drought stress, and tree regeneration will all increase in urgency. Looking out towards the mid-21st century, nearly all types assessed here would benefit from a set of resilience-based strategies, so these investments in the near-term may limit needs for more extreme measures later in the century.

Resistance vs. resilience vs. transformation strategies

More generally, some have categorized climate change adaptation strategies into three areas, including resistance, resilience, and facilitated transformation (Hansen et al. 2003, Millar et al. 2007, Chambers et al., 2014). Where vulnerability assessments indicate low vulnerability over upcoming decades, management can concentrate on resistance-based strategies; aiming to prevent ecosystem degradation. Where moderate to high vulnerability is indicated, strategies focused on restoring resilience are the priority. Where vulnerability is indicated as being very high over upcoming decades, options for facilitated transformation may need to be identified.

Resistance strategies - Areas that may face low exposure to stress from climate change and have characteristics conferring inherent adaptive capacity, including large contiguous area, high biophysical variability, ecological intactness, and connectivity. High biophysical variability might occur in lands with high topographic and microclimate diversity and in waters with highly variable temperature regimes. Traditional strategies of preventive land and water protection apply well to these areas. An emphasis on ecological monitoring is appropriate in these to help detect anticipated change among sensitive species and ecological processes, with insights applicable to understanding change occurring elsewhere.

Resilience strategies—In areas of moderate climate change exposure, high biophysical variability may confer initial advantages because species are more likely to have both space and time to move to nearby locations retaining suitable habitat conditions as climate changes. However, past and current uses of land and water may have resulted in moderate levels of habitat degradation to many component ecosystems and species, both of which need to be managed to increase connectivity and potential for range shifts. Strategies in these areas can emphasize the restoration of composition, structure, dynamic processes, and connectivity that would occur during the planning cycle (e.g., the upcoming decades) had there not been previous intensive land uses. Preventive measures, such as removal of invasive species, likely remain feasible as strategies in these circumstances. Effects of altered disturbance regime may also be feasibly addressed but should anticipate climate-induced effects of the upcoming decades. Within existing contiguous blocks, conservation design might emphasize maintenance or enhancement of biophysical variability, and especially in arid regions, options to maximize drought refugia should be explored (Klein et al., 2009).

Strategies for assisted transformation— In places facing high climate change exposure; they may have low biophysical variability and, due to severe degradation, may require the most intensive management interventions focused on component ecosystems and species (Kates et al., 2012). Abating key non-climate stressors (e.g., altered ecological processes) will tend to be the more costly from the cumulative effects of multiple stressors and species extirpations. Maximizing linkages among remaining areas and enhancing permeability of the surrounding matrix would maximize opportunity for species movement and minimize disruption to key ecological processes (Rudnick et al., 2012), even though this comes at increased risk of facilitating expansion of invasive species (Dukes and Mooney, 1999). These are areas where failure to conserve target elements is most likely and the need for “managed translocation” is most likely (McLachlan et al., 2007; Butt et al. 2020). One can anticipate that transformations to novel ecosystems will be concentrated in these areas, so strategies may center on maintenance of key ecosystem functions and services (Jackson and Hobbs, 2009).

Evaluating and selecting adaptation strategies

Choosing among adaptation strategies will depend on a range of factors, depending on the installation’s particular needs, interests, and resources. Defining explicit criteria for use in evaluation and comparison of alternatives in terms of important values or benefits. Stein et al. (2019) suggest one approach for evaluating among possible adaptation strategies is to develop assessment criteria in the following general categories, including effectiveness in meeting INRMP goals, effectiveness in sustaining mission requirements, and feasibility. Evaluation questions should include: how well do the different strategies enable the installation to achieve its natural resource management goals? How will they perform in sustaining core mission requirements for the installation? And how practicable or realistic will it be to implement the various strategies or actions?

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8.5. Monitoring ecosystems and landscapes

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Introduction

Broadly defined, monitoring refers to repeated measurement over time to provide information about changing conditions. As noted previously, monitoring could provide an “early warning” of changing conditions that require management attention. Here we provide information on types of monitoring and guidance on design of monitoring landscapes and ecosystems that is consistent with common DoD practices. Monitoring is a key part of the adaptive management cycle, in which information is gathered to determine if management objectives are being advanced or whether management strategies and targets may need to be changed.

In the context of adaptive management, monitoring should always be linked to management goals and objectives. General guidelines from DoD and other land management agencies suggest that the design of a monitoring program first start with planned management strategies and targets. These may be informed by inventory and assessment, as described previously. For example, the first and last steps of guidance for establishing monitoring programs within the Bureau of Land Management include Step 1: “Develop management objectives...” and Step 12: “...use monitoring results to apply adaptive management.”

Although a monitoring program may apply many of the same techniques used in natural resource inventory and assessment, such as measurement of plant cover and density, monitoring is applied over time to detect and document change. Most effective monitoring programs are both directly tied to management issues and are designed to be sensitive to detecting change that is relevant to management.

Types of monitoring

Monitoring can be broken into types based on purpose. The two most common purposes include: 1) implementation monitoring, and; 2) effectiveness monitoring. Implementation monitoring answers questions like “did we do what we said we would do?” and is tied directly to planning documents that spell out where and when certain actions are to be taken. Effectiveness monitoring answers questions like “did the treatment have the effect that was intended?” It could be implemented over large areas and timeframes to document regional trends or at a local site to evaluate specific response to vegetation treatments. For our purposes here, we focus on effectiveness monitoring, but these same methods could apply to baseline, surveillance, or validation monitoring (Figure 8.8).

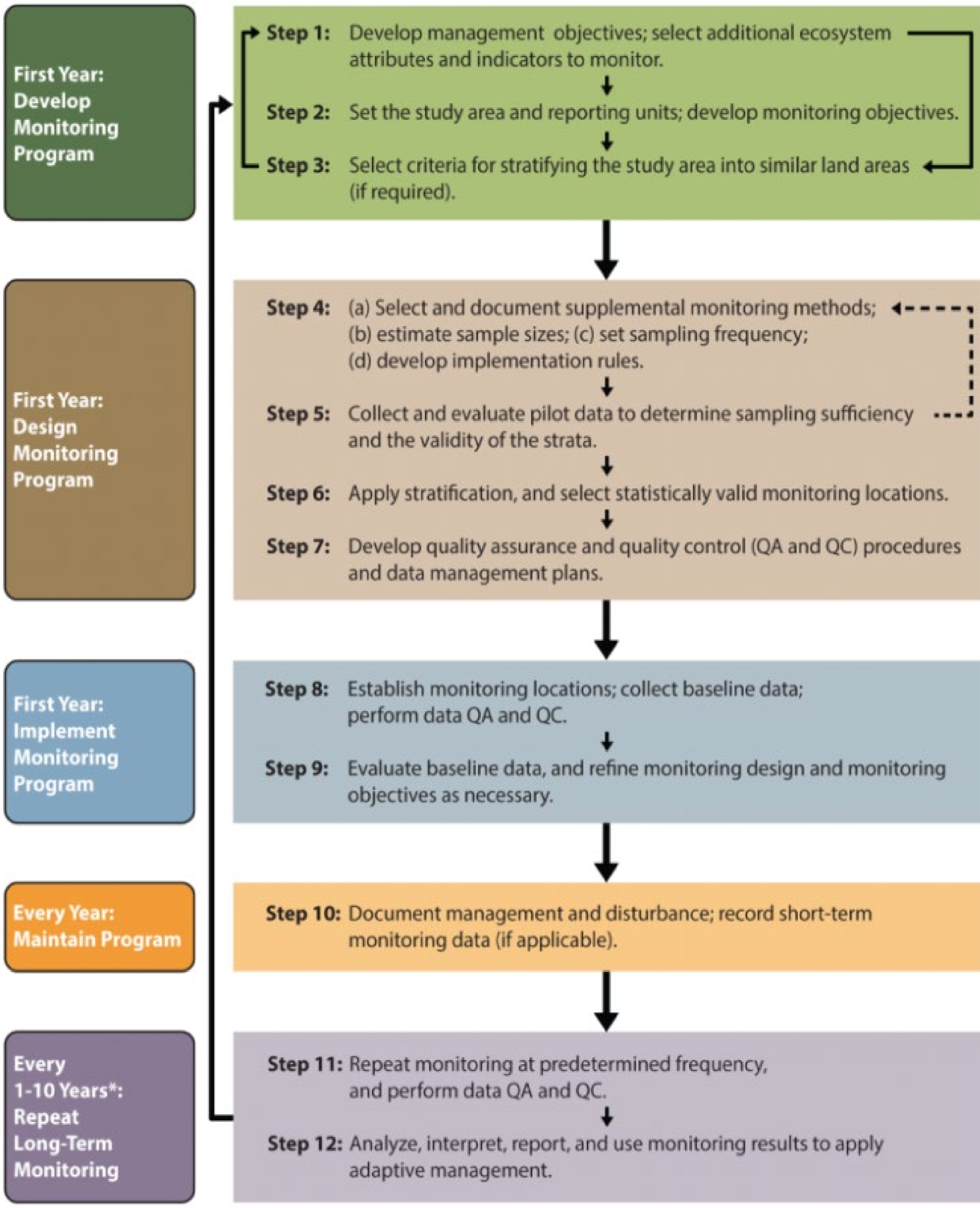

Figure 8.8 Monitoring design guidelines from Herrick et al. (2017) for use by the Bureau of Land Management.

Baseline measurement establishes initial conditions or conditions that existed prior to anticipated change. In special cases where natural resource damages have occurred, the baseline is a description of conditions that would have existed had the damage (e.g., discharge of oil or release of the hazardous substance) not occurred. It documents the relevant attributes, such as vegetation, soils, wetland hydrology, that will be the focus of management. Once established, the practitioner can then review these conditions relative to management or restoration objectives for the site and determine if all or just a subset of measures might be addressed in monitoring.

Surveillance monitoring on DoD lands is addressed in part through the Land Condition Trend Analysis (LCTA) Program. LCTA sampling is designed to measure attributes that may trigger management action on a given installation.

Effectiveness monitoring may utilize selected LCTA samples to measure progress towards desired conditions as established in the restoration plan.

Validation monitoring is typically applied over long timeframes and sites and LCTAs to test assumptions about the causal relationships between the implementation of restoration practices and their outcomes.

Table 8.1 Several commonly used terms for different types of monitoring that one might encounter in natural resource management along with their brief description, management objective and example measurement.

Type	Description	Management Target / Action	Example Measure
Baseline	Establish initial conditions to compare with subsequent measurement.	What is the current/initial level of invasive annual grass cover?	Mean percent area of cheatgrass during peak green-up (from line transect or sample plot).
Surveillance	Ongoing monitoring of ecological attributes that may trigger management action.	If cover of invasive species exceeds 20%, implement control measures (herbicide application).	Mean percent area of cheatgrass during peak green-up (from line transect or sample plot).
Effectiveness	Measure progress towards desired conditions identified in management plans.	Increase big sagebrush canopy cover to above 10%.	Mean woody canopy cover of sagebrush (from line transect or sample plot).
Validation	Documents repeated patterns in effectiveness to document causal relationships between practices and	Maintaining cover of sagebrush above 20% will support sage grouse nesting success.	Mean woody canopy cover of sagebrush (from line transect or sample plot) and sage

	management objectives.		grouse nest success measures.
Implementation	Documents, in measurable form, the plans that are implemented.	Document that vegetation treatment was implemented according to standards by the predetermined time.	Herbicide treatments were implemented for allotment 00701 in June, 2018 and for allotment 01062 in May, 2019.

Establishing monitoring goals and objectives

As described above, the first step in monitoring should generally be the establishment of goals and objectives. They should be developed to help determine whether broader management goals are being met. For example, general management goals may be to maintain or improve current conditions of a system over time. This requires knowledge of existing conditions and reference conditions that may be used to establish the state of a system in relation to target goals. In addition, while management goals may be more general or aspirational, monitoring objectives should be practical and specific in how they relate to actions and decisions in pursuit of management goals. One set of guidelines commonly used to set practical objectives are S.M.A.R.T. criteria, that objectives should be:

1) Specific 2) Measurable 3) Achievable 4) Results-oriented 5) Time-fixed

In the context of a sagebrush-dominated landscape, an example objective may be to increase sagebrush cover to a target level within a focal area. Table 8.2 presents an example with a S.M.A.R.T. goal of increasing cover to the specific and achievable level of > 15%, within seven years, measurable through application of line-point intercept assessment of sagebrush cover in a set of LCTA style sampling plots.

Table 8.2. Example monitoring objectives in relation to adaptive management and a target management goal of preventing conversion of sagebrush within a target area to juniper woodland.

Management Objective	• Prevent conversion of sagebrush dominated vegetation in target area to juniper woodland.
Example Treatment	• If density rises above 15 trees per hectare or percent cover of juniper rises above 5%. Conduct hand or mechanical removal of junipers within target areas

Monitoring Objectives	• Determine juniper density with an accuracy of +/- five trees per hectare every five years for the next 15 years. • Determine percent juniper cover with an accuracy of+/- 2% annually for the next 15 years. • Track the effectiveness of juniper removal treatments at reducing junipers 5 years following treatment.
Monitoring Actions:	• Assess juniper tree density counts on LCTA plots within target area at five-year intervals through tree-density counts at the plot level. • Assess aerial cover of junipers annually using interpretation of annual satellite imagery within target areas. • Assess juniper tree density counts on LCTA plots within treatment areas five years after juniper treatment.
Potential Adaptive Responses	• If juniper cover exceeds targets, implement juniper removal. • If removal is effective at reducing juniper cover below targets, continue treatments when juniper targets exceed threshold. • If removal is not effective at reducing juniper levels below management targets, revisit treatment options and management goals.

Monitoring indicators

The range of indicators and metrics that can be used to assess condition over time in relation is broadly addressed above under indicator metrics, which notes that indicators of ecological conditions can be identified and assessed at different levels (Brooks et al. 2004, Wardrop et al. 2013) depending on the purpose and design of the project. Level 1 (Remote Assessment) relies primarily on remote sensing-based indicators. Level 2 (Rapid Field Assessment) uses relatively simple semi-quantitative or quantitative condition indicators that are readily observed in the field, often supplemented by a stressor checklist (see below). Level 3 (Intensive Field Assessment) requires detailed quantitative field measurements and may include intensive versions of some of the rapid metrics (Stein et al. 2009).

A primary source for methods used on Army lands is the Land Condition Trend Analysis (LCTA) Program, which has gathered natural resource condition data since the 1990s (Diersing et al. 1992). A parallel and relevant program on Bureau of Land Management (BLM) lands in their Assessment Inventory and Monitoring Program (AIM), and DoD managers may find these current methods of interest. Because the BLM's AIM program presents a set of core and supplemental monitoring metrics, sample design, and sampling frequency (default of five years), relevant to monitoring vegetation condition, we refer readers to these metrics and methods as the preferred first option for selection of monitoring metrics. These methods may be added to from a list of semi-standard supplement methods, in addition to custom metrics that may be project specific (e.g., custom soil or vegetation metrics assessed within an BLM plot to address a target question). The methods established by BLM are vetted and selected for relevance to managers and present a means of leveraging agency-wide investment in monitoring. For example, the core BLM methodology of permanent and repeated measurement of vegetation along line-point intercept transects is not only highly accurate and repeatable (Elzinga et al. 1998). It is supported by standards of calibration and training for crews conducting this sampling, as well as by automated data-collection assistance through the USDA's Database for Inventory Monitoring and Assessment (DIMA). Table 8.3 presents a list of standard core and supplement methods that the Bureau of Land Management uses and can be utilized for selection of monitoring metrics.

Table 8.3. BLM Core and Supplement methods and potential indicators that can be utilized in monitoring and assessment. These methods are emphasized here as they present a standard framework and protocol in use across BLM field offices.

BLM Core Methods	**Indicators**
Line Point Intercept	Bare ground, plant species cover, litter cover, mortality
Plot species Inventory	Species richness/ presence of target species
Vegetation Height	Average height, variability, max height
Gap Intercept	Proportion of soil surface characterized by canopy gaps
Soil Stability	Soil aggregate stability
Photo points	Varied indicators that may be seen in photos (e.g. dominance of invasive species, vegetation structure).
BLM Supplemental Methods	Indicators
Forb Diversity	Average number of forbs/acre, number of preferred sage grouse forbs/acre
Compaction Test	Level of soil compaction
Describing Indicators of Rangeland Health	17 specific categorical and quantitative measures of condition related to rangelands
Infiltration	Infiltration rate (mm/hr)
Plant Production	Overall or taxon-specific levels of annual production (pounds/acre)

Plant Density	Density of target plant species
Tree Density	Density and size of tree species

Resources

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- Sampling Frequency and Monitoring Methods:
- The Landscape Toolbox (USDA ARS) a comprehensive monitoring resource tailored to the needs of USDA: https://www.landscapetoolbox.org/
- Example sample size requirements tool from the Landscape Toolbox (Multi-scale Sample Requirements Evaluation tool
- BLM AIM Core Methods: Herrick, J.E., J. W. Van Zee, S. E. McCord, E. M. Courtright, J. W. Karl, and L. M. Burkett. 2017. Volume I: Core Methods; Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems, Second Edition. USDA – ARS Jornada Experimental Range. Las Cruces, New Mexico. 86 pp.
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9. Managing for Threatened, Endangered and At-Risk Species

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Introduction

Although landscape-scale conservation is by far the most cost-effective means of preserving biodiversity, some species can fall through cracks in protection and decline to the point that they need targeted management to prevent extinction. Several species were already reduced to perilously low populations by the time the conservation community reached a consensus on the importance of landscape-scale conservation in the 1990s. Others simply have unusual habitat requirements or small ranges that make them naturally susceptible to imperilment. These species need targeted conservation actions to prevent further population decline and extinction.

The numbers of Threatened, Endangered, and Sensitive (TES) species occurring on military bases may seem disproportionately high relative to other sites. This observation likely is the result of the protection that bases confer on natural ecosystems compared to private lands that have widely been converted to agricultural and housing development. Regardless, because of legal concerns and the potential for interfering with the military mission on bases, TES species require special attention. In this chapter, we discuss TES species, describe tools that are available to work with them, and explain some of the more popular strategies for protecting them.

Threatened, endangered, and sensitive species

In this manual, Threatened and Endangered species refers to those that have received designations under the Endangered Species Act (ESA); see Chapter 4 “Laws, Policies, and Program Related to Conservation and Natural Resource Management on and Around DoD Lands” for more information about the ESA. ‘Sensitive’ species are those with characteristics and threats that make them likely to qualify for Threatened or Endangered status under the ESA. Sensitive species include those designated by the U.S. Fish and Wildlife Service (FWS) as ‘candidates’ for listing (i.e., the species warrants listing but cannot be listed yet due to higher priority work within the listing program) and may include ‘petitioned’ species (i.e., species that the public has formally requested the FWS review for listing consideration). Some federal land management agencies have specific definitions for sensitive species or use alternative labels for these species.

The immediate goal of managing Threatened and Endangered species is to prevent them from becoming extinct, with recovery and delisting as a longer-term goal.

Management of sensitive species is not subject to the strict legal constraints and outside scrutiny of Threatened and Endangered species, allowing for more creativity in designing recovery plans. Management success, though, is still critically important to achieving the goal of keeping these species off the ESA list and consequent land use restrictions that could result. Base managers will want to include management plans for each of these species in their Integrated Natural Resource Management Plans (INRMP).

Concepts and regulations with endangered species

Because many bases harbor Endangered and Threatened species protected by ESA, base managers should be familiar with provisions of the Act. Here is a brief review of ESA concepts relevant to Department of Defense (DoD) personnel.

Authority—The FWS is responsible for the listing, conservation, and recovery of terrestrial and freshwater species whereas NOAA (specifically, the National Marine Fisheries Service) assumes these tasks for marine species. This distinction is important because the FWS Environmental Conservation Online System (ECOS) database—an excellent source of information on listed plants and animals—has no information on listed marine animals. For these species, refer to NOAA's database on Threatened and Endangered species.

Listing factors—NOAA and the FWS consider five factors in their decisions about whether species merit listing:

1. The present or threatened destruction, modification, or curtailment of its range
2. Overutilization for commercial, recreational, scientific, or educational purposes
3. Disease or predation
4. The inadequacy of existing regulatory mechanisms
5. Other natural or manmade factors affecting its continued existence

Critical habitat—Areas of habitat believed to be essential to the species' conservation, usually defined as part of a listing decision. These areas are mapped spatially.

Recovery plan—Unique plans for each listed species that describe how federal agencies and other partners will collaboratively work to conserve the species. Recovery plans have measurable criteria and are reviewed every five years.

Section 7 Consultation—Section 7 of the ESA requires federal agencies to consult with FWS or NOAA to ensure actions carried out by the agency do not jeopardize listed species or adversely modify their critical habitat.

Section 9 ‘Take.’—Section 9 of the ESA prohibits the taking of listed species, including both direct harvest and adverse modifications of their habitat.

One reason that INRMPs are so important is that the FWS and NOAA will not designate critical habitat on bases if satisfactory measures are taken to protect Threatened and Endangered species in INRMPs. This arrangement allows the wildlife protection agencies to ensure that effective conservation is taking place while giving bases flexibility to coordinate their military mission with natural resources management.

Planning for TES species management

Management for TES species typically involves four steps that are often embedded into a larger conservation plan that includes ecosystem targets. First, managers assess the TES species occurring on the base. Depending on the current state of knowledge, this investigative stage could help identify TES species occurring on the base, identify population sizes and trends, map distributions and seasonal movements, and identify threats. The assessment may also look at species’ status off site to determine DoD’s management responsibility (for example, what proportion of a species’ range or population occurs on the base). Second, managers plan strategies to protect and, if needed to recover species to achieve specific management goals. Next, managers act to implement strategies. Finally, managers monitor for implementation of strategies, threat abatement (if needed), and the response of the target population. Depending on the monitoring results, strategies can be adjusted to increase success. The following sections describe details and tools used to carry out these basic management steps.

Determining TES species present on a base

The charismatic Threatened and Endangered species present on a base will likely be well known. Base managers will have dealt with these species for years. Lesser-known species, especially those that recently attained Candidate or Proposed ESA status may require field surveys to determine presence or absence on a base. Also, because of climate change, species that previously did not occur on a base may show up and make themselves at home.

Networking is a good way to stay on top of changing ESA status and species movements. A good relationship with the local FWS office is key to receiving alerts about species status. NatureServe Network Programs in the U.S. (sometimes referred to as “state natural heritage programs”), and the non-game offices of state fish and wildlife agencies are also good resources for species information.

The population of species found on bases can play an important role in influencing that species’ status or listing decision. If a base has good examples of habitat that has declined elsewhere, it may have an unusually healthy population of the species in question. And because the base is off limits to casual observers, scientists and biologists compiling the FWS Species Status Assessments to inform listing decisions may not know of that population. Additionally, base personnel may be unaware that a species is present until a proper survey is performed. The value in conducting a survey for a species under review is that it could reveal previously unknown healthy populations. This information could mean the species is less threatened than thought, tipping the balance away from the need for formal legal protection—a win for everyone.

Once the list of target species or a species group is compiled, the next step is to determine where to look for them. Knowledge of the species' habitat requirements and a good vegetation map of the base can help to narrow down the search area. In the absence of a useful habitat description, plotting localities for the species from NatureServe Network Programs or online data aggregators such as Biodiversity Information Serving Our Nation (BISON) or Symbiota Collections of Arthropods Network on a vegetation map can give useful clues. Sometimes the notes associated with digital locality records include habitat description. A more powerful approach is to use a habitat model to predict where suitable habitat for the species occurs on a base (see below in Tools for Assessment).

- For field surveys, unless base personnel have experience surveying for a particular type of organism, a partnership with experts is essential to conducting the survey. Partners ideally have authoritative experience with a sensitive species and can perform field work using proper methods at an appropriate time of year under favorable weather conditions, and then report on whether a particular species does or does not occur on a base. Potential partners may include: Partners in Amphibian and Reptile Conservation (PARC)
- Partners in Flight (PIF) for birdsocal native plant societies for rare plants
- NatureServe Network Programs in each state (expertise is extensive for a wide range of organisms)
- Universities (varies, but universities with wildlife management programs are a good place to start). Biologists at these institutions might also be able to refer local contractors with expertise in surveying specific groups of organisms.

Tools for assessment

Once a TES species is documented to occur on a base, decisions about which management strategies will have the greatest chances of success will typically require more information about the population. This assessment step can answer the following questions:

- Where does the species occur?

- How much of the species' global population occurs on my base?
- Is the population expanding or contracting?
- Is the population viable?
- Has the population undergone genetic bottleneck, leaving it with perilously poor genetic variation?
- How is climate change affecting the population?
- Are any diseases or invasive species affecting the population?

A brief discussion of some of the tools available to answer these questions follow. Most of the tools are outside the realm of expertise of base environmental personnel, so again partnerships with academic institutions (especially military-specific research programs such as the Center for the Environmental Management of Military Lands at Colorado State University) or a state NatureServe Network Program can be valuable.

Mapping the Distribution of Species

If a field survey confirmed the presence of the species on a base, an extension of the survey to all potential suitable habitats can inform a map of the distribution on the base. If no survey has been conducted, consider taking that step. Being able to map out locations of individuals, habitat patches, nest sites, or some other indication of the species' presence on a base is a powerful tool for understanding potential conflict with other base objectives such as training and target practice, as well as for identifying management strategies. There are about as many ways to conduct surveys as there are species to survey for. As suggested above, in most cases establishing a partnership with a competent agency or contractor is the best way to have a base surveyed for a particular species or species group.

Prior to conducting a survey or in cases where the suitable habitat is too remote or impractical to survey on the ground, consider running a habitat model for the species (Guisan and Thuiller 2005). Habitat models, also known as species distribution models, use an algorithm, coordinates of where a species has been observed, and relevant spatial environmental data such as climate, soils, vegetation type, and topography to predict where suitable habitat for the species is distributed across the modeled area. The more accurate the locality data and the more tightly a species is associated with the environmental predictor variables, the better the model will perform at predicting where the species occurs. These models require experience, access to high-resolution spatial environmental data, and a computer facility to process the data. The outputs can be highly informative for directing survey efforts or understanding how much of the land and water area of a base supports habitat for a species.

Management responsibility

As discussed in Chapter 6 “Partnerships to Achieve Conservation Goals and Sustain Training,” effective conservation often depends on coordination with public and private landowners in the region surrounding a base. One piece of information that can inform interactions with neighbors as well as the investment in management of a species is the relative management responsibility of a base. If a base has one of the largest populations of a species (for example, gopher tortoise on Eglin Air Force Base in Florida), then investment in its protection is likely very important compared to a situation in which a base has a small population that is one of dozens for a species. Calculation of management responsibility requires information about sizes of populations across the species range, distribution maps, or habitat models run for the entire range. Be careful with small populations—satellite populations at the edge of a range might have unusual genetic variation that is important to the evolutionary potential of the species. Be aware also that a base may become increasingly favorable habitat for a species as the climate changes.

Tracking population trends

Knowing population size and how fast it is increasing or decreasing are fundamental inputs into management decisions but often surprisingly elusive metrics to come by. Species vary tremendously in their natural histories and life cycles, typically requiring tailored monitoring approaches for different species. Approaches include measuring the size or percent cover of occupied habitat, counting individuals or egg masses, and using models to estimate occupancy of habitat patches. As for surveying, population monitoring must take place during appropriate seasons and weather conditions. In some situations, base personnel can conduct the monitoring rather than relying on a partner. Regardless of who does the monitoring, an often-overlooked aspect is managing and archiving annual measurements to support future long-term analyses.

Population viability

What’s the chance that a population will persist over the next X years? A population viability analysis (PVA), a modeling approach that estimates a population’s risk of extirpation, can answer this question (Traill et al. 2010). PVA will work only on well-studied populations with a good run of population trend data and other information to estimate parameters for the model. Done well, PVA can support a sensitivity analysis that identifies the factors and life stages having the greatest influence on the future population trends. This information is invaluable for deciding how to invest resources in different management strategies.

Conservation genetics

Small or isolated populations are always in danger of losing genetic variation and succumbing to inbreeding and the accumulation of deleterious genes. Knowing a population's genetic diversity is valuable for determining its risk of extirpation from one of these factors. Methods for measuring genetic variation advance rapidly and vary widely across species. A partnership with an academic lab with the equipment needed to run the analyses is key. Although many genetic measurements require invasive sampling (plant leaves or animal blood), increasingly noninvasive techniques such as the use of scat samples are becoming available.

Climate change vulnerability assessment

A climate change vulnerability assessment (CCVA) helps understand how and the extent to which climate change threatens a population (see Chapter 8, "Managing Landscapes and Ecosystems"). CCVA approaches for TES species may focus on species' traits or use habitat models run with future projected climate data as inputs to estimate vulnerability (Foden et al. 2019).

Diseases and invasive species

Both diseases and invasive species can have devastating impacts on species of interest. Managers at island bases are well aware of the destructive power of invasive predators and competitors such as pigs, goats, and rats. Species of interest on mainland bases are also susceptible to invasive plants that outcompete native plants.

Strategies

Armed with a list of TES species and assessment of their populations and potential stressors, base managers can then consider strategies to slow or stop declines or enhance existing populations. Here we list some common strategies for management interventions of TES species. As with many of the tools listed in this chapter, outside help is typically needed to carry out these actions due to the high technical expertise needed and public scrutiny that comes with working with high profile species.

Habitat management—Natural resource managers have designed countless ways to manage habitats for TES species. The most straightforward is to restrict human entry and disturbance to the habitat used by the target. Restrictions can be limited to a targeted time period if harmful activities take place when the target species has either migrated elsewhere or is in an inactive phase. For example, restricting access to cliffs where peregrine falcons nest can be limited to the breeding season. Training during the rest of the year will have little impact on the falcons as long as artillery practice does take aim at the cliffs. On the other hand, off-season use of heavy vehicles in areas with vernal pools used for reproduction by rare amphibians can compact soils and negatively affect hydrological periods.

Many forested ecosystems, especially those dominated by conifers and grasslands require fire at appropriate frequency to maintain their function. Controlled or prescribed burns are often critical to maintaining the integrity of these systems to promote regeneration of desired tree species and reduce understory vegetation. Timing is key for successful controlled burns. The season for burning should be chosen to avoid affecting the target and nontarget species, and the specific date of the burn should coincide with favorable weather conditions. The spatial scale of burns is another important consideration as some species benefit from a mosaic of habitats that result from small-scale fires burning in different years.

Invasive species management is often called for when invasive species are major threats. This practice can take many forms depending on the nature of the threat, from eradication of introduced mammals on oceanic islands to the use of controlled burns to reduce the expansion of invasive grasses. Herbicides are sometimes used for aggressive invasive plants with no other practical means of control. Biocontrol through the release of animals (often insects) or disease agents, although attractive in theory, has had mixed results and requires a careful analysis of benefits and risks (Heimpel and Cock 2018). In some cases, native species such as white-tailed deer have become super abundant and require population control similar to that used for invasive species to reduce impacts on target species (Pendergast et al. 2015).

Where food limitation limits breeding success or juvenile or adult survivorship, food supplementation may benefit target species. Supplementation may be direct (e.g., setting out cow carcasses for California condors) or indirect by planting vegetation that provides food resources, enhancing the habitat for prey species, or, in extreme cases, reducing populations of competitor species. A good assessment study will be valuable to identify the life stage that would benefit from food supplementation to avoid unnecessary expenditure of resources on what is typically a resource-intensive management action.

Other habitat enhancements may help replace missing features in an ecosystem to the benefit of a target species. For example, nest boxes can substitute for woodpecker holes in old growth trees, artificial burrows can be used where gopher tortoises have disappeared, and artificial ponds and wetlands can make up for the loss of natural ones.

Restoration—Restoration is an extreme form of habitat management where the goal is to return a system to some historical state. In practice, the aim is typically to recover a natural range of ecosystem composition, structure, and dynamics. In the context of TES species, managers employ ecological restoration to recover aspects of an ecosystem that have been lost but are needed for the population to prosper. As highlighted above, military bases often have exceptional examples of natural ecosystems and therefore less need for restoration. However, to fulfill the needs of a target species, restoration may be called for in some cases. The base might have an abandoned training area, airstrip, landfill, or other site that could be converted into a wetland, grassland, or forested habitat. Because restoration is often the most expensive management action available, decisions about embarking on such a project should be carefully considered and executed with advice from experienced professionals.

Ex situ conservation—Ex situ conservation is a strategy to consider for species occurring in habitats that have become too degraded to sustain the population even with intensive habitat management or other in situ actions. Again, military bases often have extensive intact ecosystems such that ex situ conservation will rarely be necessary. It might be an option, for example, if a small population of a TES species is newly discovered in an area that has already been heavily degraded by training or for base infrastructure and the population is in imminent danger of extirpation. Any ex situ conservation efforts will most likely involve coordination with FWS personnel that can take the lead in providing access to the necessary captive rearing facilities. For plants, the FWS is also an important ally but the botanical garden and seed banking community are additional resources.

Translocation—Another high-profile strategy, translocation, involves moving individuals from one site to another. Translocation has been used to augment genetic diversity of an isolated subpopulation by bringing in individuals from different subpopulations. An entire subpopulation under threats that are beyond immediate mitigation can be translocated to another area where the chances of survival are higher. Currently, one of the threats that can trigger such an action is climate change. If a climate is becoming unsuitable to the point of threatening the persistence of a subpopulation and natural dispersal is prevented (e.g., by anthropogenic barriers), then translocation to a site with a more favorable climate may be the option.

Deciding between alternative strategies

Sometimes the strategy needed to protect a species is obvious. Perhaps a TES amphibian is not reproducing because the temporary pools where they reproduce always dry up before the tadpoles can undergo metamorphosis. Adding water to the pools to increase the hydroperiod will probably be successful. More often, there is enough uncertainty around the results of an assessment such that the best strategy is unclear. Uncertainty around how the climate might change and how a species will respond can suggest multiple plausible strategies, each with a different cost. How do we determine which to pursue?

The best bet is to undergo a structured decision-making process. Identifying clear objectives, alternative actions, how different actions might affect outcomes, and risks can provide a transparent framework for deciding among alternative strategies.

Fortunately, structured decision making is now widely used in natural resources management and there are many resources available to learn from.

Resources

Endangered Species Act:

- "Endangered Species 101" - a video by the FWS: https://www.youtube.com/watch?v=Y6wJpGO8j4Q
- FWS ECOS database of Threatened and Endangered species: https://ecos.fws.gov/ecp/
- NOAA database of Threatened and Endangered marine species: https://www.fisheries.noaa.gov/species-directory/threatened-endangered

Species Locality Databases:

- Biodiversity Information Serving Our Nation (BISON)—federal mapping resource for species occurrence data in the United States and its Territories and Canada, including marine Exclusive Economic Zones (EEZs): https://bison.usgs.gov
- Symbiota Collections of Arthropods Network (SCAN)—occurrence records and images from over 100 North American arthropod collections for all arthropod taxa: https://scan-bugs.org

Habitat Models:

- Guisan and Thuiller (2005): https://onlinelibrary.wiley.com/doi/full/10.1111/j.1461-0248.2005.00792.x
- Rubric for decision-quality habitat models (Sofaer et al. 2019): https://academic.oup.com/bioscience/article/69/7/544/5505326

Population Viability Analysis and Conservation Genetics:

- Genetics and PVA (Frankham et al. 2013): https://sdmmp.com/upload/SDMMP_Repository/0/9jnykz5tfwcbsg0mhvqd76312x4r8p.pdf
- PVA Target setting (Traill et al. 2010): https://www.sciencedirect.com/science/article/abs/pii/S0006320709004017
- PVA and threatened species management (Morrison et al. 2016)
- PVA programs: VORTEX (https://scti.tools/vortex/), RAMAS-GIS (https://www.ramas.com/gis-6-0)

Climate Change Vulnerability Assessment of species:

- Comprehensive review of CCVA methods (Foden et al. 2019) (http://ccsg-iucn.com/wp-content/uploads/2018/10/Foden-et-al_2018_Climate-change-vulnerability-of-species_FINAL.pdf)
- Climate Adaptation for DoD Natural Resource Managers (Stein et al. 2019): https://www.nwf.org/DoDAdaptationGuide

Restoration Ecology:

- Textbook: Foundations of Restoration Ecology (Palmer et al. 2016)

Translocations:

- IUCN Guidelines for reintroductions and other conservation translocations: https://www.iucn.org/content/guidelines-reintroductions-and-other-conservation-translocations
- Overview book on reintroductions, which includes much information on translocations: Reintroduction Biology: Integrating Science and Management (Ewen et al. 2012)

Structured Decision Making:

- Accessible overview to SDM: “Smart Choices: A Practical Guide to Making Better Decisions” (Hammond et al. 2002)
- Practical guide for natural resource managers: “Structured Decision Making: A Practical Guide to Environmental Management Choices” (Gregory et al. 2012)
- Compendium of case studies in natural resource management: “Structured Decision Making: Case Studies in Natural Resource Management” (Runge et al. 2020)
- The National Conservation Training Center often runs courses in structured decision making for natural resource managers (https://training.fws.gov/)

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10. Invasive Species Management

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NOTE: Hawai`i is spelled in the way preferred by many natives of the archipelago, with the reverse apostrophe. For some reason "Hawaiian" does not take the apostrophe.

Introduction

Non-native invasive species are a leading threat to our nation's rich biodiversity, as well as to national security, the economy, and human health. Since colonial periods, thousands of non-native species have been introduced to the United States, some by accident and others quite deliberately. Based on the U.S. Department of Agriculture (USDA) Plants Database, currently 13 percent (5,303 of 40,140) of the vascular plant species in the nation are not native to North America. These would include most of Americans' favorite foods and many ornamental plants. The majority of non-native plants and animals existing in the U.S. are not harmful, but some non-native species cause tremendous damage when released outside of their native habitats. As defined by Executive Order 13112, invasive species are those non-native species that "cause economic or environmental harm or harm to human health." The Congressional Office of Technology Assessment reported in 1993 that 15 percent of invasive plants and animals cause severe economic and environmental harm.

Invasive species occur throughout the lands and waters of the United States, and military lands are no exception. These invaders are a major and growing problem on military lands, impacting the ability to train the nation's armed forces, degrading ecosystem health of these public lands, endangering native biodiversity, and potentially causing harm to human health. The military faces some unique challenges in combating invasive species on their lands, challenges related to their primary goal of maintaining the quality of military lands for realistic training exercises, while also meeting their responsibility to safeguard the quality of natural resources and biodiversity on their lands.

Numerous military installations across the country have employed successful and innovative methods to control invasive species, examples of which will be referred to throughout this chapter and in the case studies. Given the vast amount of land that the military owns and manages in the United States, the military has a unique responsibility in managing for invasive species and in helping to prevent new introductions. The Department of Defense (DoD), however, cannot stop the problem of invasive species on its own. Invasive species are a "beyond the fenceline" issue that must be addressed comprehensively, by Congress and other state and federal public land management agencies, as well as by private entities and individuals. Given the far-reaching nature of this problem, DoD has formed many diverse partnerships in battling invasive species, some of which are highlighted below.[58]

Impacts on military operations

Invasive species affect the nation's military installations and operations worldwide. The National Wildlife Federation's recent report (Westbrook and Ramos 2005) on invasive species on military lands provides twelve cases outlining numerous threats and costs to military operations: from six-foot tall spiky yellow star-thistle shredding parachutes that average $4,000 apiece to *Phragmites* causing security concerns at Avon Park Air Force Range. Holloman Air Force Base allocated over a half million dollars to remove invasive species from airstrips in order to protect the safety of Air Force pilots and prevent damage to aircraft worth tens of millions of dollars. And in Hawai`i, dense non-native mangrove thickets can breach "line of sight" security for Marines assigned to protect base borders along the shoreline (Westbrook and Ramos 2005).

Ecological impacts

Many reports have documented the ecological impacts of these non-native invaders, including citing invasive species as one of the greatest threats to biodiversity (e.g. Stein *et al.* 2000). Worldwide, an estimated 80 percent of endangered species could suffer losses due to competition with or predation by invasive species (Pimentel *et al*. 2005). In addition to direct competitive impacts to native species, some of the worst invasive species are able to alter native habitats and ecosystems. Invasions by non-native species have been shown to modify ecosystem processes, like nutrient cycling, fire frequency, hydrologic cycles, sediment deposition, and erosion (Kelly 2007). On the Marine Corps Base Hawai`i, non-native mangrove stands take over native marsh habitats, converting critical habitat for endangered Hawaiian waterbirds into mangrove thickets that are inhospitable to both native species and to realistic military training exercises on base. On Avon Park Air Force Range in Florida, invasive wild hogs compete with the endangered Florida scrub jay for food and destroy nesting habitat for many other endangered species (Westbrook and Ramos 2005). Such feral hogs are a growing menace at several other military

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[58] Some general sources of information about invasive species can be found at the National Invasive Species Information Center (http://www.invasivespeciesinfo.gov/); the National Fish and Wildlife Foundation (http://www.nfwf.org/), and http://.tncweeds.ucdavis.edu/ or http://www.invasiveplants.net/.

installations. When invasive species cause habitat destruction and harm rare native species, the result can lead to reductions in available training lands on installations.

Economic impacts

Invasive species impact the United States economy in many ways, negatively affecting economic sectors such as western ranching, Great Lakes shipping, southern forest plantations, and midwestern farming, just to name a few. Within the U.S., the estimated damage and management cost of invasive species is more than $138 billion annually, more than any other natural disaster (Pimentel *et al.* 2005). In addition to these costs, many economic losses from recreational and tourism revenues are difficult to calculate (Simberloff 2001); as a result, the $138 billion estimate may be low.

If monetary values could be assigned to the extinction of species, loss of biodiversity, and reduction of ecosystem services, costs from impacts of invasive species would drastically increase (Pimentel *et al.* 2005). For the military, the costs related to invasive species are significant and are increasing each year. To name one example, Camp Pendleton in southern California spent approximately $1.2 million over a five-year period trying to control giant reed (*Arundo donax*) and tamarisk (*Tamarix ramossima*) (Westbrook and Ramos 2005). While it also can be expensive to prevent invasive species on military lands—for example through programs to wash tanks and other military vehicles before and after transport—prevention is a critical first-line defense against new invaders on military lands. Once established, managing invaders such as the giant reed and tamarisk, mentioned above, can often be a multi-year and multi-million-dollar effort.

Recreational impacts

As many boaters and fishermen can attest, invasive species like water hyacinth (*Eichhornia crassipes*), hydrilla (*Hydrilla verticillata*), Eurasian milfoil (*Myriophyllum spicatum*), and water chestnut (*Trapa natans*) can reduce or prevent access to water bodies. In some cases, it is the recreational activities that have introduced or spread invasive species. So have people out for innocent walks; *Miconia calvescens*, a broad-leafed plant introduced as a handsome ornamental in Hawai`i in the 1960s, produces tiny seeds that must be removed from shoe soles by vigorous brushing, lest they plant themselves elsewhere. It and other invasives can limit hiking options or reduce the outdoor experience. Conservative estimates of the economic costs from invasive species impacts on wildlife-related recreation in Nevada alone range from $6 million to $12 million annually (Elswerth *et al.* 2005).

Invasive species vectors

Invasive species have arrived in the United States through a multitude of means, including introductions by early human settlers who seek reminders of their homelands, to importation of ornamental plants, to introductions by government agencies to combat some other problem (often an agricultural one), to an expanding global trade enterprise that inadvertently allows the rapid spread of species. Modern trade has increased the spread of several species. Asian tiger mosquitoes hitchhike into new areas in rainwater pools in discarded tires and even aboard water-filled depressions on ship structures. This mosquito is associated with the transmission of many human diseases, including dengue virus, West Nile virus, and Japanese encephalitis (Global Invasive Species Database 2006).

Ship ballast, typically water pumped into a ship's tanks at one port and pumped out at another, is used to balance the weight and control the steerage of freight vessels and is a well-documented vector. The most noted species introduced by ballast is the zebra mussel. Zebra mussels (*Dreissena polymorpha*) are native to the Caspian Sea, but long ago began spreading throughout much of Europe. In 1988, they were detected in the Great Lakes where they had caused serious problems by out-competing native species for food and damaging harbors, boats, and power generation plants.

In some cases, the military itself unintentionally may have been responsible for the spread of invasive species. While it is difficult to pinpoint the precise time, location, and cause of introduction, there is speculation that the military introduced the brown tree snake to Guam, African iceplant to the San Francisco Bay area, black rats to the Midway Islands, and sakosia shrubs (*Timonius timon*) to Palau. The military has taken a leadership role to reduce future unintentional introductions. The Armed Forces Ballast Water Management Program, which requires DoD vessels to twice flush ballast water at least twelve nautical miles from shore, should be used as an example to commercial vessels. Transportation policy and procedures rules already require the washing of vehicles after field operations. The primary purpose is to extend the life of field equipment, but it also has a secondary purpose of reducing hitchhiking foreign pests from entering U.S. borders.[59]

Federal guidelines for invasive species

The United States has several legal guidelines that are intended to prevent and combat invasive species. Chief among them is the National Invasive Species Act of 1996. This act is a reauthorization and amendment to the 1990 Nonindigenous U.S. Aquatic Nuisance Prevention and Control Act of 1990 (P.L. 101-646), which authorized the National Oceanic and Atmospheric Administration and the U.S. Fish and Wildlife Service (FWS) to address aquatic invaders. Section 1103 of the 1996 act states that the "Secretary of Defense shall implement a ballast water

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[59] See *Retrograde Washdown: Cleaning and Inspection Procedures.* Armed Forces Pest Management Board. Technical Guide No. 31. November 2004.

management program for seagoing vessels of the DoD and Coast Guard (see http://www.nemw.org/nisa_summary.htm). The act also calls for the creation of state invasive species management plans, development of ballast water guidelines for commercial vessels, research studies, and demonstration projects. Advocates of the ballast program argue that the act needs reauthorization that includes the program's expansion to cover all commercial vessels similar to that of the armed services program. The Aquatic Nuisance Species Task Force (http://www.anstaskforce.gov/default.php) is an intergovernmental group that helps to implement the act. There is also a hotline to report sightings of aquatic nuisance species (ANS) in the U.S. (Telephone 877-STOP-ANS; http://cars.er.usgs.gov/Nonindigenous_Species/Stop_ANS/stop_ans.html)

Executive order 13112, Invasive Species

Executive Order 13112, which was signed in 1999, created the National Invasive Species Council (NISC) that is composed of 13 federal departments and agencies, including the DoD. The council's principal objectives are to prevent the introduction of invasive species, monitor invasives' populations, promote restoration of native species, and promote public education on invasive species. (http://www.invasivespeciesinfo.gov/laws/execorder.shtml). A five- year review of the NISC was recently completed (see: http://www.invasivespeciesinfo.gov/docs/council/fiveyearreview.pdf). This document highlights the accomplishments to date and the NISC's future plans.

Armed Forces Pest Management Board

This board (http://www.afpmb.org) provides numerous resources regarding invasive species and other pests impacting military lands and operations. The AFPMB has developed best management practices, standard pesticide uses guidelines, resources for identifying invasive species, and links to research activities. The AFPMB publishes technical guidance for installation personnel who are responsible for pest management plans.

Combating invasive species

The most cost-effective means to control invasive species is to prevent their initial arrival. The impacts of many of these species, however, are not understood until they are well established. For those species where environmental and economic impacts are known, measures need to be taken to reduce the risk of introduction, including survey for these species at ports of entry and military bases where equipment and materials are imported or returned from foreign soils. Military vessels and equipment used in foreign lands where invasive species are suspected should be thoroughly cleaned before leaving those foreign lands. If any invasive species are found at our first lines of defense (i.e. shipping ports), then immediate eradication should occur.

On military lands where invasive species are already present, management activities should include restoration actions. The removal of invasive species without restoration can lead to the reestablishment of the same or new invasive species. Furthermore, on many installations, there is a chance that invasives species can reinvade from lands outside the installation boundaries. On Avon Park Air Force Range in Florida, the highly invasive and problematic climbing ferns and tropical soda apple occur in public and private lands nearby. It is important for military natural resources managers at all installations to think beyond the fenceline and cultivate public and private partnerships to keep invasive species under control.[60]

Early detection/rapid response

The idea of early detection/rapid response is a two-part component: first, surveys to identify newly established invasive species, and second, an effort to eradicate newly detected infestations. There are many cases where early detection has identified newly established pests, but managers have proven less adept at following up with eradication programs. Many scientists want to study the problem more, but agencies are bogged down in red tape that prevents immediate eradication. Given the potential environmental and economic impacts, a suggested strategy of "yank it now, ask questions later" may prove most cost effective. This is particularly important for species that are known to cause harm.

Mechanical control

The use of mechanical control is often effective for dealing with small, newly established populations or as part of a large-scale restoration program. Mechanical control may simply include hand pulling or the use of large equipment. No matter what control feature is employed, follow-up monitoring is necessary to ensure eradication.

Pesticides

Many modern pesticides have been vastly improved over earlier controls, such as DDT, with its notorious residual environmental impacts. Methodologies for applying pesticides have also improved. Cut-stump treatments (i.e. painting herbicides directly onto a cut surface), wet wicking (hand applying herbicides to individual target plants), and stem injections (the use of needles to inject herbicides directly into a target plant or impacted plant) allow applicators to directly apply chemicals to the target species with little or no non-target impacts. In extreme cases, broadcast spraying of herbicides may be viewed as the only option, in which case more care and review are needed. DoD has a goal that by 2010, all pesticide applicators will be

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[60] For more on beyond-the-fenceline thinking, see Chapter 6.

certified. Drawbacks to chemical treatment include its cost and harm to the environment and the persons to handle the poisons.

Biological controls

Biological controls are growing in use as non-chemical opponents of harmful invasive species and diseases. Biocontrols can be defined as the use of natural enemies, usually from a pest's native lands, to reduce the impact of problematic insects, diseases, and plants. There are many examples of successful use of biocontrols in the place of chemical poisons; a tiny parasitic wasp, part of a large group of parasitoids, controls many agricultural pests and diseases, for example. The Texas Agricultural Experiment Station has collaborated with the DoD to remove noxious weeds on military lands. The weeds include leafy spurge, field bindweed, spotted knapweed, Canada thistle, and St. John's Wort; participating installations include Fort Carson Military Post, the Air Force Academy, Rocky Flats Environmental Technology Site, Buckley Air Force Base, and F.E. Warren Air Force Base.

As with any effort to tinker with Nature, biocontrol can have unintended, negative results. One danger is that the biological control agent—parasitoid, fungus, nematode, bacterium, competing organism, growth regulator—can gobble up or infect not only its intended target but also beneficial organisms. In the 1970s, for example, biologists released the Asian ladybug to control aphids that were attacking pecan trees in the southeastern U.S. These ladybugs were successful at eradicating these aphids, but they also had appetites for other insects. The result has been a biocontrol that eats so many aphids and other native ladybugs that many of native ladybugs became threatened or extinct. Even New York's official state insect, the nine spotted ladybug (*Coccinella novemnotata*), is now extinct from New York State because of competition with the Asian ladybug.

These and other examples should be viewed as cautionary tales. When biocontrols are thought to be the only solution, detailed research and extensive testing must be done. Researchers and land managers need to learn from the biocontrol failures. They need to ensure that biocontrols do not become the next wave of invasive species, potentially worse than the species they were meant to control. But if carefully evaluated before introduction, biological controls can be highly effective, as Jerry Johnson at Fairchild Air Force Base, Washington, can attest (see case study). Biocontrol agents are tightly controlled by the U.S. Department of Agriculture.

Partnerships

As a member of the National Invasive Species Council, the Armed Forces Pest Management Board works with multiple agencies to combat invasive species. Throughout the country, Cooperative Weed Management Areas (CWMAs) or similar partnerships are forming to address invasive species problems across multijurisdictions. These partnerships may allow the DoD, along with other federal agencies, state agencies, NGOs, and local land managers, to share resources and experiences to better manage invasive species.

Conclusions

As with any land manager today, the military's first line of defense against invasive species must be prevention of new invasions and preventing expansion of existing invaders. The military already has many policies in place to aid in prevention, such as DoD's Customs and Border Clearance Program Regulations, but consistent funding is needed for prevention programs to be successful. Since funding is often linked to an installation's Integrated Natural Resources Management Plan (INRMP), prevention of invasive species should always be considered in the INRMP, along with early detection, rapid response, and long-term management of invasives.

Perhaps the most important weapon in the fight against invasive species on any installation is outreach and partnerships. Installations such as Fort McCoy have enlisted the help of citizen volunteers in controlling numerous invasive plants, such as garlic mustard and leafy spurge, on their base. Staff at the Wisconsin fort have reached out to local stakeholders and developed partnerships to educate the community about the harmful impacts of invasive species on and off base. These partnerships have even aided Fort McCoy with bringing in funding for their efforts, through the National Fish and Wildlife Foundation's "Pulling Together Initiative" which provides grants for public and private partnerships to combat invasive species (Westbrook and Ramos 2005). The military can also form very beneficial partnerships with conservation organizations and invasive species researchers, to share resources, information, and best practices in the battle against invasives. The military has teamed with nongovernmental organizations, such as The Nature Conservancy, to combat some of the nation's worst invaders, such as tamarisk or salt cedar.

Not only do installation natural resources managers need to look outside their borders to form partnerships, but they also should look to their own operational forces as partners in controlling invasive species. In some cases, management of invasive species can be aided by training activities, such as on the Marine Corps Base Hawai`i, where Marines help clear out invasive pickleweed by running their amphibious assault vehicles over the invaded mudflats, helping to improve the habitat for native species such as the endangered Hawaiian stilt while simultaneously improving the training ranges for military maneuvers (Westbrook and Ramos 2005).

Managers of lands invaded by undesirable species also must consider native biodiversity and the entire ecosystem. When addressing the problem of invasive species in an INRMP, natural resources managers should always consider what they are managing for, not only what they are managing against. For example, in some cases, restoration efforts are necessary after invasive species have been removed from an area. Moreover, when managers think holistically, they are more likely to minimize any harmful environmental impacts of invasive species control efforts. Herbicides and biocontrols can be very useful management tools in some situations, but any potentially harmful side effects also must be examined, and the benefits weighed against the possible long-term costs. Partnering with other public and private land managers and with researchers in universities who have expertise in invasive species control can be critical for military natural resources managers seeking and testing the most cost effective and least environmentally harmful invasive species control methods.

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11. Balancing Biodiversity Conservation with Multiple Uses

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Introduction

Today's management of military lands is increasingly sophisticated and is the product of a range of influences both direct and indirect. This chapter focuses on incorporating biodiversity management into military land use. But first, a basic understanding of how military land uses developed over the years—by understanding the legal and sociological origins of today's military land uses—commanders and land managers should be able to successfully incorporate biodiversity management into the installation multiple-use mix.

Training has always been the primary use of military lands. However, since their establishment, military reservations have served additional purposes in response to national priorities, mission needs, public pressure, and advances in land management practices. Military installations—including training and testing lands, ammunition manufacture and storage plants, and depots and terminals—have incorporated forestry, agriculture outleasing, and hunting and fishing land uses into daily operations because they provide a variety of benefits. Military lands are also managed for natural resources, threatened and endangered species, cultural resources, and a range of environmental compliance related issues.

Box 11.1: What is multiple use?

The Department of Defense (DoD) defines multiple use as "[T]he integrated, coordinated, and compatible use of natural resources so as to achieve a sustainable yield of a mix of desired goods, services, and direct and indirect benefits while protecting the primary purpose of supporting and enhancing the military mission and observing stewardship responsibilities." https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/471503p.pdf?ver=2019-02-28-120916-070.

Forest operations and agriculture outleasing

Forestry was one of the first non-military training land uses to be incorporated and was part of an expanded military use. World War I demonstrated the military's need for wood products and in 1918 the military established its first forestry program at the U.S. Military Academy at West Point, New York, for the purpose of producing timber.

In the first half of the twentieth century, military reservations were not particularly extensive, but erosion and wildfires were ongoing problems. Woodlots and forested areas had to be managed due to the buildup of fuels, and Forest Service advisors, following their mandate of water supply protection and continuous timber production, recommended wildfire and erosion control measures through active forest management programs that included timber production.

In the 1940s there were about 3 million acres (excluding Alaska) under military control, but by the 1960s the figure had increased to nearly 30 million acres. This large land area required the knowledge and experience of professional land managers, foresters, and agronomists. Subsequent installation land management under these professionals progressed beyond land stabilization and wildfire management, to non-military uses including timber production and agriculture outleasing for crops and grazing. These added land uses not only helped to maintain military lands in good condition and suitable for training, but also saved military labor costs and provided financial support for the forestry and agriculture outleasing programs. In many cases, lands acquired by the military were often in poor condition and unsuitable for training. Many were former farm lands or otherwise devoid of forest or native vegetation, and it was critical that these lands be revegetated. Under the direction of the Forest Service, many of these lands were converted to forest, which was then managed for timber production.

In 1956 Congress provided authority for the military departments to retain the receipts from the sale of forest products, and this led to a significant increase in timber production by the military—between 1956 and 1963, gross income from military forest lands increased from $10.5 million to $26.7 million. Today, surplus funds (after installation forestry program expenses and state entitlements[61] are paid) are deposited into the DoD Forestry Reserve Account. The DoD retains a minimum balance in this account to fund emergency forestry program contingencies that may arise. But the DoD annually returns some of the excess funds in the account to the individual services for

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[61] 10 USC 2665 grants a 40 percent entitlement of annual net forestry sale proceeds to the installation host state or states. The states distribute the funds to the appropriate host counties to be used to build, maintain, and fund roads and schools.

forestry enhancement programs, or in some cases, for general natural resources projects. (LRMP 2005, Part 3-24).

Box 11.2: Multiple use as a national policy

Demand for wood products for the post-World War II housing boom coincided and competed with an increased demand for recreation and wilderness and a concern for environmental values. These changes in public attitudes and the need to balance competing demands led to the concept of multiple-use which was declared national policy in two Congressional acts—the Multiple-Use Sustained Yield Act of 1960, which applied to the Forest Service, and the Classification and Multiple Use Act of 1964, which applied to the Bureau of Land Management.

The World War II period also saw the introduction of outleasing of military lands for agriculture. For a fee, farmers could apply to lease military lands around airfields, ammunition storage areas, and other grasslands or arable land where grazing or crop production would not interfere with military activities. At first, income from outleases was deposited into the U.S. Treasury and it was not until later that outleasing became the Reimbursable Agriculture and Grazing Program, allowing the military services to retain agricultural receipts and use them to fund natural resources projects at their individual installations.

The establishment of the reimbursable program had the effect of increasing incentives to offer land for lease and outleasing was promoted by the military as an inexpensive land management option. The lessees often provided in-kind services on leased lands, often in lieu of cash rent, such as mowing, weed and brush control, fence construction and repair, drainage maintenance, fire lane construction, and rodent control. Agriculture and grazing operations on the leased lands were also important for fire control because the underbrush and grasses that could fuel fires were reduced.

Hunting, fishing and recreational uses

The restoration of military lands and conversion to forest brought an increase in wildlife populations, and so hunting was introduced on some installations to assist in controlling populations of deer and other game species. Consistent hunting policies did not exist for military installations until the passage of the Engle Act[62] in 1958. The act tried to resolve basic conflicts between the military and civilian conservation agencies by requiring that

[62] Engle Act. 10 USC 2671 et seq. (1958).
https://www.bliss.army.mil/homepage/mrlwr/docs/engleact.pdf

all hunting, fishing, and trapping on military installations be conducted in accordance with state and federal laws, and under the appropriate state licenses.

On most installations, commanders restricted hunting privileges to the military and their dependents until passage of the Sikes Act of 1960, which authorized public recreational access and the collection of fees by installations for that privilege. This led to the widespread opening of military areas to public recreation. Although outdoor recreation included camping, picnicking, boating, swimming, and a host of other outdoor activities, hunting and fishing were in greatest demand by the public at that time. Fees collected for hunting and fishing activities are used to cover administrative expenses and support conservation initiatives. Unlike forestry and agricultural lease fees, hunting and fishing fees must only be used for funding activities on the installation from which they were collected.

Managing for biodiversity—as an added multiple use

By the early 1990s, military training and testing lands were being used not only for direct mission support but, when appropriate, were also supporting forestry (primarily timber production), agriculture and grazing on outleased lands, and recreational hunting and fishing. These three land use programs continue to provide a range of benefits to the military, and are usually economically self-financing and in some cases, are significantly profitable. Funds raised by these programs have benefited natural resources management on installations throughout the nation and have significantly benefited the quality of military training lands by supplementing the limited funding designated for natural resources management.

Military training and testing activities have intensified considerably due to the Base Realignment and Closure Act (BRAC) of 1988, and subsequent BRAC actions, which have resulted in the closure and realignment of military bases throughout the country. Remaining installations now accommodate more troops, many rotations, and a diversity of training activities, and are under continual pressure to sustain their ranges and maintain military readiness while remaining stewards of the land. They achieve this by following a comprehensive and integrated ecosystem management approach, implemented through the Integrated Natural Resources Management Plan (INRMP) process, and which aims to balance an installation's various activities and land uses with its military mission requirements.[63]

Conserving and improving native biodiversity is the first principle of DoD's ecosystem management approach (DODI 1996). Just as military lands are managed for use as training lands, and for forestry, agricultural outleasing, hunting and fishing, and recreation, so too they can be managed for biodiversity. When regarded as a

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[63] See Chapter 5 for a discussion of the INRMP process.

management initiative, biodiversity can readily be incorporated into all facets of land management through the installation’s INRMP. Goals and objectives for biodiversity management should be identified in the INRMP, and then integrated with the installation’s training requirements, and with other natural and cultural resources management goals and objectives. Its explicit inclusion within the INRMP means that actions that benefit biodiversity, as well as actions that may negatively impact biodiversity, will be clearly identified and monitored through the INRMP review and update process.

Strategic planning for biodiversity management

Planning for the conservation and/or enhancement of biodiversity on installations with multiple land uses requires that a strategic approach is taken to ensure ecosystem integrity and sustainability. Ecological integrity is one of the operating tenets of ecosystem management and maintaining system integrity is consistent with DoDI 4715.3 (1996). Ecosystem integrity, as defined by Angermeier and Karr (1994), is "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitat of the region.”

Biodiversity management involves restoring, protecting, conserving, and enhancing the variety of biological resources. When land use goals vary or conflict with biodiversity conservation, then biodiversity management must be proactive and protective. Restoring biodiversity once it has been harmed is not simple damage repair. In some cases, repair may not be possible, and so every effort must be taken to protect and conserve biodiversity.

Conserving biodiversity in the context of multiple land uses and within the confines of DoD lands has indisputable merits. However, the benefits are more likely realized when they extend “beyond the fence” and are conducted within a regional context, and when they are defined more by ecosystem considerations than by legal or political boundaries. Initiatives such as the Army Compatible Use Buffers (ACUB) Program—initially a 1995 Army initiative—provide an opportunity for installations to pursue biodiversity conservation goals beyond the installation boundary. ACUBs present the opportunity to more effectively manage for biodiversity by incorporating approaches over large scale regional and sub-regional landscapes—a primary tenet of ecosystem management.

To meet the challenges of biodiversity conservation, specific long-term biodiversity management goals and objectives should be developed and the associated actions and projects should be identified and described, and incorporated into an installation’s INRMP. During the annual INRMP review and update, resource managers and planners should consider the following biodiversity points for military training, and for other installation land uses (agriculture, hunting, fishing, recreation, special management areas, etc.):

- Determine biodiversity priorities for each specific land use.
- Estimate the ecological conditions necessary to sustain the biodiversity priorities.
- Identify alternative land use strategies that may have less impact on or benefit biodiversity.
- Develop monitoring objectives and methods that include biodiversity and are based on the stated management goals and desired future scenarios.
- Develop and implement adaptive management as needed when uncertainty of the outcome is high or when previous efforts have been less than successful.

Specific considerations for biodiversity management are outlined below for the typical installation land uses—forestry, agriculture outleasing, hunting and fishing, recreation, special natural areas, and training lands.

Biodiversity management in forestry and silviculture programs

Managing forest biodiversity at an installation requires consideration of landscape elements of scale, disturbance, fragmentation, and habitat. At the local level, forest stand attributes such as structural diversity, crown closure, fuel loads, soils, standing dead trees, coarse woody debris, tree species diversity, and large wildlife trees, have a direct impact on biodiversity. When considering the various forest elements critical to biodiversity, it is also essential to consider the interaction of forests with other habitats, and the interdependence of habitats (e.g. unimproved grassland, wetlands, and hedgerows).

Regardless of size, forests can provide habitats for a range of flora and fauna. Even small, recently established forests within otherwise intensively cultivated land can be useful, although the scope may be limited due to isolation and, in certain circumstances, they can harbor pest species. Forest management scales are generally defined by human-made or jurisdictional boundaries (e.g., landscape unit, watershed, forest stand) and on military installations by mission-related requirements. They do not necessarily apply to biological systems and managers may need to adapt them to accommodate more biologically sound scales. This may require coordination with local and regional neighbors.

Natural disturbances are important to biodiversity and help shape plant and animal communities. For example, areas with high fire frequency have more early-successional taxa than areas with longer intervals between fires (Bunnell 1995). The degree to which species have co-evolved with and are dependent on natural disturbances varies with the species. However, at some scale, all species require natural disturbances for persistence (Bunnell 1995).[64]

Disturbances due to forestry practices have different impacts on biodiversity than natural disturbances. Natural disturbances interact with the geology, climate and vegetation, and result in a complex mosaic of habitats at the landscape scale, while conventional logging, such as clearcutting, tends to homogenize the landscape. This can be compensated to some degree by creating snags, leaving standing and downed dead wood, and using other means to create a mosaic of habitats.

Within the landscape context, fragmentation and habitat loss are two separate processes (Andren 1994, With and King 1999). Two areas may have the same amount of habitat, but the spatial arrangement of remnant habitat and thus, the amount of fragmentation within each, can be drastically different. Fragmentation of forest habitat into smaller isolated patches reduces the total amount of habitat area, increases edge effects around habitat patches, reducing the core area, and increases patch isolation. Current research findings suggest that overall habitat loss has a much larger effect on biodiversity than the spatial arrangement of remnant habitat (Fahrig 2001).

Biodiversity management strategies for managed forests should be applied in the preparation of forestry plans; silviculture prescriptions, and logging and fire management plans. To maintain or restore biodiversity in managed stands, some or all of the following attributes should be present:

- Structural diversity is achieved when there is a variety of canopy layers (vertical structure) and spatial patchiness (horizontal structure). This creates more habitat and micro-climate diversity than in homogeneous stands. Structural diversity can be maintained or created through the choice of silvicultural system, harvesting methods, and stand-tending activities such as tree planting, pruning, fertilization, and pre-commercial and commercial thinning.

- Soil biodiversity can be achieved by forest soils management and forest practices that minimize soil disturbance help maintain the below-ground biodiversity. Soil structure, nutrient spectrum, organic matter content, water retention, drainage, and pH combine to determine the vegetative composition of ecosystems.

- Standing dead trees provide nesting and foraging habitat for many species. Some existing snags in managed forests should be retained, but equally important is ensuring that new snags will be recruited into the stand in the future.

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[64] For more on disturbance, see Chapter 2 and 8.

Small diameter snags are adequate for some species, while large diameter snags are required by other species and endure longer.

- Coarse woody debris from decaying logs on the forest floor provides cover, micro-climates, and breeding habitat and should be retained in the stand. Larger size pieces are preferable as they provide the greatest longevity and potential for nutrient cycling and wildlife use in second-growth forests. Coarse woody debris is rarely evenly distributed, but it should be well distributed throughout the stand, if possible.

- Tree species diversity can provide habitat for a greater variety of organisms than that provided by a homogeneous stand. When applicable, an ecologically appropriate variety of tree species, including hardwoods, should be retained in a stand.

- Large wildlife trees are any standing live or dead trees with special characteristics that provide valuable habitat for conservation or enhancement of wildlife. Characteristics include large size; condition, age, and decay stage; evidence of use; valuable species types; and relative scarcity. These trees serve as critical habitat (for denning, shelter, roosting, foraging, and establishment) for vertebrates, insects, mosses, and lichens.

Biodiversity management for agriculture outleases for range and crop lands

Outleasing of areas for agriculture affects biodiversity directly by converting natural habitats to cultivation, grazing, or other manipulation, and through the associated repeated disturbances that accompany conversion. Agriculture affects biodiversity indirectly through water management practices for irrigation and drainage, soil erosion and sedimentation, and elevated nutrient and pollutant discharges into the environment.

Agroecosystems (agricultural ecosystems) can be mosaics of pasture, cropland, woodland, and wetlands, and this patchiness may benefit some species. Agricultural lands may provide more suitable habitat for native wildlife and birds than do fragmented and extensively modified urban or suburban lands. When developing agriculture management plans, it is important that the resource manager consider the compatibility between biodiversity and agriculture, with key considerations being habitat availability, species at risk, as well as the potential for economic damage to agriculture caused by wildlife. At the landscape level, agriculture can best preserve biodiversity when it incorporated as part of a matrix of habitats connecting natural areas. In agroecosystems, the conservation of aquatic biodiversity requires consideration of impacts to aquatic systems from agricultural nonpoint source pollution and the potential effects on aquatic ecosystem structure and function from altered hydrology (Blann 2006).

Habitat and threats from non-native and invasive species in agricultural lands directly compete with biodiversity goals. Approximately 46 percent of the plants and animals federally listed as endangered have been negatively impacted by invasive species (USDA 2006). The significant threat of invasive species to biodiversity increasingly is being recognized both internationally and domestically. Biodiversity goals and objectives outlined in the INRMP should include contingencies for impacts resulting from invasive and non-native species. Early warning of possible negative impacts is possible when biodiversity management includes monitoring and adaptive management measures.[65]

Grazing and rangeland

Rangeland and pasture management has typically focused on simplifying ecosystem structure and achieving uniform disturbances across a landscape. Most rangeland and grazing management techniques were developed under the model of increasing and sustaining livestock production by decreasing the rangeland diversity. This approach is obviously incompatible with biodiversity management and prevents development of an ecological framework for alternative management objectives. Maintaining biodiversity and preserving habitats for many individual species is contrary to the typical range management model and depends on the interspersion of diverse habitat types throughout a heterogeneous rather than a homogeneous landscape (Fuhlendorf and Engle 2001).

Grazing management includes fencing needs, water development, seeding, brush control, fertilizing, salt distribution, and intensified animal husbandry (Laycock 1983). Management can be aimed at improving range biodiversity with careful study of the desired plant species, their phenological characteristics, how they respond to grazing pressures during each annual season, and annual re-seeding (Gayaldo 1996). For example, light to moderate grazing of grasslands, oak forests and savanna habitats can potentially promote plant and associated vertebrate wildlife diversity (EBMUD 2001).

Many of the biological-physical-management interactions associated with rangeland biodiversity are only beginning to be understood (West 1993). However, a number of studies have shown that grazing does affect the vegetational composition of a community (Gayaldo 1996). Long periods of time (several decades) are required for significant vegetational changes to occur in rangelands, and are dependent on soil and climatic conditions, competing species, and available native seed sources. Also, it is documented that more time is required for a site to progress from a poor to fair condition than from a fair to good condition (Gayaldo 1996). Livestock grazing and rangeland practices that pertain to water quality protection are also applicable to habitat protection, and the maintenance and enhancement of biodiversity. This is particularly true for

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[65] For more on invasive species, see Chapter 10.

riparian and aquatic habitats when livestock access is excluded by establishing buffer zones, and by providing alternate water supplies for livestock. Prescribed grazing, livestock exclusion, fencing and control location and timing of livestock impacts, are commonly used to protect and enhance plant and wildlife diversity. Also, establishment of proper stocking rates and judicious monitoring form the basis for biodiversity management on outleased watershed lands that are grazed.

Biodiversity guidelines that may be applicable to grazing management at some military installations include the following (taken from the East Bay Range Resource Management Plan [2001]):

- Identify high-priority sites for habitat restoration based primarily on water quality protection and on the value of restored habitats and locations relative to important wildlife use areas and corridors.
- Monitor listed species populations and conduct site surveys.
- Identify key habitat areas necessary for protection and management of special-status plants and animals. Provide buffer areas to reduce disruption of nesting and roosting areas for sensitive wildlife species.
- Recognize the ecological value and likely permanence of certain non-native species and habitats (e.g., annual grassland), and incorporate the management of these species and habitats into biodiversity planning efforts.
- Use prescribed fire, periodic grazing, mastication (chipping trees on site with either a mulcher head or hydro-axe), or other means to discourage shrub encroachment and maintain grassland conditions where annual grazing has been eliminated from grassland habitats and grassland retention is a biodiversity priority.

Croplands

In the United States there have been substantial changes in the mix of cropland and pastureland over the past century (Blann 2006). The expansion of crop production over hay and pasture production has been accompanied by more intensive farming practices, increased farm size, and reductions in shelter belts, field borders, wetlands, and remnant habitat areas that were previously inconvenient to farm. Fencerow-to-fencerow farming has reduced biodiversity by eliminating much nesting, feeding, and winter cover for wildlife (Blann 2006), and croplands do not provide the stubble fields and harvested grassland habitats important to many invertebrate, bird and small mammal species.

The influence of agriculture on biodiversity often goes beyond farmed land itself, as the majority of semi-natural habitats are linked to the surrounding agricultural land and may be fragmented or isolated within the larger agricultural landscape. Cropland practices which may impact biodiversity include fertilizer use; monoculture; abandonment of farmland; removal of field margins such as hedges, ditches, and fencerows; poor drainage and irrigation, and soil erosion.

It is possible to provide a balanced environment, sustained yields, biologically mediated soil fertility, and natural pest regulation through the design of diversified agroecosystems and the use of low-input technologies (Altieri 1995). Different types of habitats in agricultural landscapes, depending upon their size, shape, and location, may support different types of biodiversity. Non-farmed areas can be used to provide patches of certain habitat types, or to form corridors linking protected areas and enabling species to maintain genetic contact between otherwise isolated populations. Such benefits can be achieved on outleases via lease agreement language and through programs such as the ACUB process. Agricultural areas can make a positive contribution to diversity when the surrounding matrix is managed with biodiversity in mind.

Blann (2006) offers the following cropland practices for biodiversity management (adapted from Granatstein [1997] and Bird et al. [1995]). These practices could readily be implemented on outleased lands through the lease agreements and enforcement procedures.

- Practice soil conservation measures. Increase protective cover on the soil surface, using no-till, cover crops, windbreaks, contour strip cropping, and grass waterways.
- Eliminate or minimize intensive row-cropping and tillage on highly erodible land, and on sensitive lands such as floodplains, riparian areas, wetlands, and steep slopes.
- Use a greater variety of crops grown in more complex rotations. This breaks weed and disease cycles.
- Enhance habitat quality to encourage and enhance wildlife diversity. Use cover crops and soil-building crops like legumes, clover, and grass. Integrate crops and livestock production with intensively managed grazing and recycling of manure to build soils.
- Use integrated pest management, in which pest levels are monitored, biological controls are used wherever available, and chemicals used only when an economic threshold is reached.
- Nutrient inputs should be managed to maximize efficiency and minimize nutrient movement to surface water and groundwater.
- Properly store and apply animal manures. Compost manures and other wastes.

- In arid regions and other areas relying heavily on irrigation, develop and implement management systems for efficient water use. Water-intensive crops that compete with instream uses often impose high costs on local ecosystems. Cropping systems should be matched to local and regional climatic and environmental conditions.

Biodiversity management for hunting and fishing, and recreational land uses

The provision of leisure and recreational activities is one of the most valued land uses in an installation's mixed-use inventory, and biodiversity frequently plays a key role. The aesthetic qualities of an area are often tied to its range of biological diversity. People value biologically diverse areas for a variety of active (hunting, fishing, swimming, cycling, hiking) and passive (photography, bird watching, contemplation) recreational pursuits.

Recreation has its impacts on biodiversity and many of these impacts have been described in detail (Liddle 1997; Newsome, Moore, & Dowling, 2002). The most prevalent impact process is trampling, which damages and kills plants, displaces soil organic horizons, and compacts mineral soils. Off-road vehicles, horse traffic, bikers, and hikers can damage fragile soils and introduce invasive species. These immediate, direct trampling effects, in turn, have additional longer lasting and cascading effects (Liddle 1997). In addition to trampling, substantial environmental effects are caused by such activities as firewood collection and campfire building, trail construction and maintenance, human intrusion into wildlife habitat, and the use of off-road vehicles.

In the field of recreation ecology, a primary conclusion is that impacts to biodiversity are an inevitable byproduct of recreation. Avoiding impacts is not an option, unless all recreational use is curtailed (Cole 2004). Managers must make decisions about appropriate levels of impact and implement management strategies that keep impacts to within their pre-determined acceptable levels. Biodiversity impacts from recreational pursuits can occur rapidly but may recover slowly. This effectively challenges management strategies based on periodically allowing sites to rest and demonstrates the importance of proactive management—avoiding impacts instead of repairing them. It also explains the common finding that impacts proliferate over time unless the sites can rest. The proliferation of impacts at new sites is usually more problematic than the deterioration of established sites (Cole 2004).

Hunting and fishing are an integral part of recreational activities on many military installations for both military personnel and the general public. When managed astutely, hunting can provide selective and area-sensitive wildlife management and be regarded as a service to farmers. However, in the United States, in some instances over-hunting has been responsible for the local extinctions of some wildlife species.

Resource managers should consider the following biodiversity management recommendations when planning for hunting and fishing, and other recreation opportunities:

- Ensure biodiversity management is integral to recreation planning and management.
- Provide educational materials and/or workshops for target audiences to raise awareness of biodiversity.
- Strengthen wildlife management policies and practices to minimize impacts on biodiversity objectives.
- Encourage low impact recreation areas such as primitive campsites.
- Implement site-specific habitat and species plans.

Special natural areas

Areas on DoD installations with natural resources that warrant special conservation efforts may be designated as special natural areas (DoDI1996). These are recognized for their unique or exceptional natural resources or cultural qualities and attributes. In most cases management is directed at preservation and/or protection of the area with very specific management objectives. However, special natural area designations on military lands cannot be set aside as permanent environmental preserves due to DoD's requirement to maintain flexibility to adapt the defense mission to political and technological developments (DoD Inst. 4715.3, para. F.1.i(4)). Even though an installation is precluded from establishing permanent environmental preserves, these special natural areas can make a significant contribution to conservation of regionally important natural resources.

Conflicting management objectives and threats to the ecological integrity of the habitat such as invasive species and encroachment can directly impact the biodiversity of the special natural areas. Developing biodiversity management and invasive species management plans will complement management measures specific to these special natural areas and can be incorporated in the installation's INRMP. Similarly, damage to cultural resources should be avoided through development of strategic planning which is incorporated into the installation Integrated Cultural Resources Management Plan (ICRMP). And both the INRMP and ICRMP should be reviewed and integrated to ensure that management of these resource categories is at best, beneficial, and at least not damaging.

Box 11.3: A special natural area

Fort Belvoir, Virginia, has designated three special natural areas: the 1,360-acre Accotink Bay Wildlife Refuge; the Accotink Creek riparian area; and part of the upland plateau of the South Post training area. The primary management goal for these significant natural areas is conservation and biodiversity. Low-intensity military training and testing, as well as low-intensity recreation, environmental education, scientific research and study can be conducted within the special natural areas if access and use are compatible with resource conservation.

Figure 11.1. Aerial view of the Accotink Creek

Military training and testing lands

The DoD is emphasizing the concept of Sustainable Operations at military training lands and ranges as an essential factor in maintaining mission readiness. Sustainable operations represent the capacity to conduct operations in a manner that preserves the resources that are necessary to conduct successful mission operations indefinitely into the future. The resources include human, natural, and man-made resources including facilities, equipment, financial and community support.

Military operations may not always be compatible with biodiversity conservation. In these instances, mitigation should be pursued with impact minimization as the goal.

Box 11.4: Mitigation or enhancement

Options for mitigation enhancement include:

- avoiding or limiting the threatening activity
- changing the timing of and/or activities involved
- applying measures that protect native biodiversity assets, such as establishing buffers or fencing
- undertaking activities that result in net gains for native biodiversity, such as replanting, removing invasive species, or implementing biodiversity protection measures

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In addition to mitigating activities that harm biodiversity, the resource manager should consider creating and/or restoring landscape components that are critical to species most at risk and that contribute to regional biodiversity. Another strategy for reducing habitat and wildlife damage that does not constrain training is to expand the environmental awareness and education programs for military personnel. Properly designed and implemented inventory and monitoring programs should also be important components of biodiversity conservation for training installations. Biodiversity conservation can be as simple as allowing fires to burn on a range, and this may, in turn, help maintain natural vegetation and native habitat. And the resulting vegetation may provide a more realistic setting for training.

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