



U.S. Fish & Wildlife Service

ENDANGERED

# Species

BULLETIN

Spring 2011

Volume 36, No.1

**Wildlife Stewardship  
and National Defense**

## In This Edition

The Department of Defense and the military services work hard to ensure that soldiers have high-quality natural environments in which to train. They also work to sustain our nation's natural resources for future generations. Achieving these dual missions requires commitment and perseverance. A few of the many projects dedicated managers have undertaken in the past 10 years are featured in this edition of the Endangered Species Bulletin. These projects not only enable the military mission, but also help to defend and sustain endangered species and their habitats.

To learn more about DoD's stewardship efforts and successes, take time to read the stories in this edition of the Bulletin. You can also learn more at its website, [www.DoDNaturalResources.net](http://www.DoDNaturalResources.net).

## Send Us Your Comments

We are very interested in your comments and suggestions about the Endangered Species Bulletin. Please send them to [esb@fws.gov](mailto:esb@fws.gov) or mail them to Endangered Species Bulletin, U.S. Fish and Wildlife Service, Suite 420, 4401 North Fairfax Drive, Arlington, VA 22203-1610.

You can also call us at 703-358-2171.

# ENDANGERED Species BULLETIN

Spring 2011

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Editor: Mike Bender

Associate Editor: Sarah Leon

Art Director: Jennifer A. Hennessey

## Contributors

L. Peter Boice	R. Fischer	Priya Nanjappa
Alison Dalsimer	M. Convertino	Ernesto Garcia
Erica Evans	M. Chu-Agor	Michael Lannoo
Kathryn Sabella	G. Kiker	Christopher Dobony
Jane Mallory	C.J. Martinez	Eric Britzke
Hannah E. Anderson	R. Muñoz-Carpena	Mark Ford
David Clouse	H.R. Akçakaya	Raymond Rainbolt
Todd Zuchowski	M. Aiello-Lammens	Dr. Joseph M. Szewczak
Bernd Blossey	Richard A. Fischer	Jim Brannen
Victoria Nuzzo	Jonathon J. Valente	Josh Wilhelm
Aaron Moody	Michael P. Guilfoyle	Howard Jelks
Donald George	Sidney A. Gauthreaux	Bill Tate
Nancy Natoli	T. Mitchell Aide	Frank Jordan
Tammy Conkle	Carlos Corrada-Bravo	Eric Wolf
Lorri Schwartz	Robert E. Lovich	Verl Emrick
I. Linkov	Chris Petersen	Douglas Ripley

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The Bulletin welcomes manuscripts on a wide range of topics related to endangered species. Please send an inquiry before drafting the article.

We invite you to visit the Endangered Species Program web site ([www.fws.gov/endangered](http://www.fws.gov/endangered)), where you can download podcasts and find links to follow us on Twitter and Facebook.

◀ **On the cover:** 2011 has been designated "The Year of the Turtle" by Partners in Amphibian and Reptile Conservation ([parcplace.org](http://parcplace.org)), an organization that counts the Department of Defense as a member. Last summer, personnel with the Air National Guard participated in a green sea turtle nesting beach clean-up on the Hawaiian island of O'ahu in cooperation with "Malama nu Honu," a non-profit group that works to protect the species through education, public awareness and conservation. Photo by © Martin Strmiska / Alamy.



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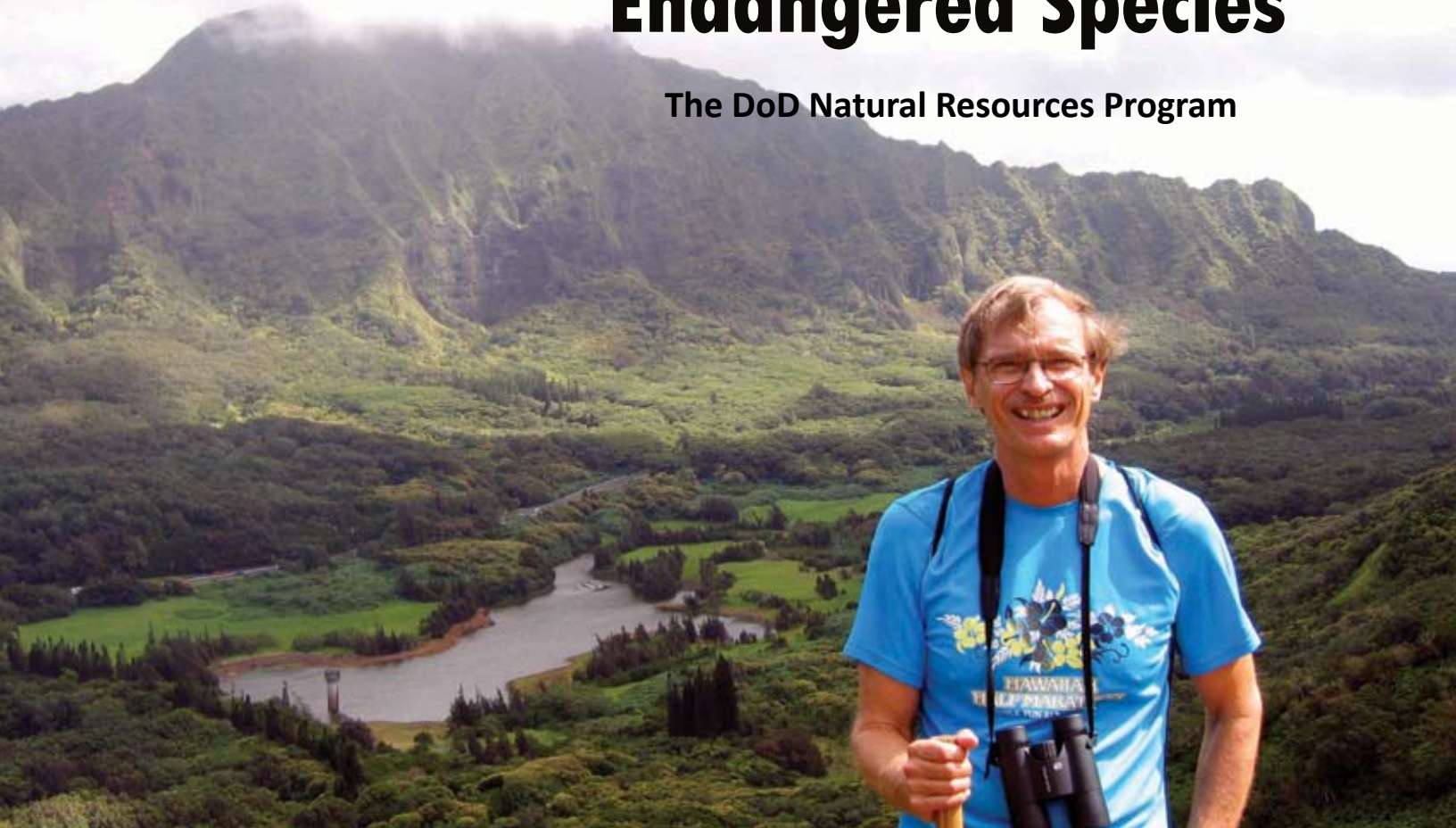
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# Why We Care About Endangered Species

## The DoD Natural Resources Program



**T**he Department of Defense (DoD) mission is to defend our nation, train our troops, and test equipment needed for national defense, peacekeeping, and emergency response. It requires air, land, and sea space for training and testing activities. Such activities may not immediately conjure thoughts of environmental stewardship. However, L. Peter Boice, Deputy Director of Natural Resources for the Office of the Secretary of Defense, offers 20 years of experience and a different perspective on this subject. During a short interview near his office in Arlington, Virginia, Peter spoke with me about DoD's commitment to natural resources conservation, and he discussed some of the natural resource policies and partnerships that have

driven DoD's successes during his career. Our conversation provides a glimpse into the extensive conservation efforts underway within the United States military, and reveals that the link between our military services and environmental stewardship is clear.

### **KS: What is DoD's natural resources mission?**

LPB: DoD's core mission is to enable our military service men and women, soldiers, sailors, airmen, and marines to train as they would fight. DoD pursues its natural resource goals to provide realistic training lands while at the same time meeting legal requirements to provide habitat for a wide variety of threatened, endangered, and at-risk species.

### **KS: Why does DoD care about endangered species?**

LPB: DoD protects endangered species to comply with the Endangered Species Act and to avoid the need for critical habitat designations, which could restrict training. To achieve this wildlife protection goal, the military services must also comply with the requirements of another law, the Sikes Act. Congress passed this law in 1960, requiring DoD to assess natural resources on installations, complete Integrated Natural Resources Management Plans (INRMPs), and coordinate with the U.S. Fish and Wildlife Service (FWS) and state fish and wildlife agencies to manage natural resources with no net loss to the military mission. However, legislative compliance is not the sole reason for

protecting endangered species on military lands. DoD manages over 29 million acres of land and more listed, threatened, endangered, and at-risk species per acre than any other federal agency. As development increases in areas surrounding military installations, some installations have become islands of biodiversity that provide habitat for certain species. In fact, more than 40 species occur only on DoD lands. DoD recognizes that part of defending our nation involves defending these natural resources for future generations.

**KS: Which DoD programs are involved with threatened, endangered, and at-risk species conservation efforts?**

LPB: There are four main programs involved with conservation efforts within DoD. I head the Natural Resources Office, which is part of DoD's Environmental Management Office. We implement the Secretary of Defense's priorities; conduct program oversight, advocacy, and outreach; and develop policy. The DoD Legacy Resource Management Program is the funding arm for the Natural Resources Office, and it provides money for national and regional projects in support of stewardship needs. The

Readiness and Environmental Protection Initiative Program works with communities that surround military installations and training areas to create buffer zones of protected habitats. This allows our soldiers to have more training space while the species that depend on those habitats can better flourish. The Strategic and Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP) fulfill DoD-specific needs for all DoD environmental programs, including munitions, restoration, weapons platforms, and natural resources. SERDP focuses specifically on research and development, while ESTCP funds technology demonstration and validation.

**KS: What are some key conservation successes that have resulted from DoD partnerships?**

LPB: DoD conservation successes not only prevent critical habitat designation and loss of training, but also create realistic training grounds for soldiers. During my career, many accomplishments have resulted from DoD partnerships with programs such as Partners in Flight and The Nature Conservancy. DoD Partners

in Flight, a public/private conservation partnership, is celebrating its 20th year by working with airfield operators to promote better habitat for species and reduce bird/animal aircraft strike hazards, resulting in potential cost savings. The Nature Conservancy works with DoD to identify lands on or surrounding bases that are prime for protection. Together, DoD and The Nature Conservancy populated a database for future land management decisions aimed at preventing the need to list at-risk species in places such as Fort Lewis, Washington, in the Puget Sound area.

**KS: What do you hope readers will take away from this issue of the Endangered Species Bulletin?**

LPB: I hope that our readers will understand that DoD's mission is to defend our nation and its resources. Our natural resource managers care about and protect threatened, endangered, and at-risk species, and I hope readers will appreciate the range of habitats and species under DoD stewardship. Most importantly, I hope that our readers leave with the knowledge that defending these species and other natural resources truly enables the military's testing and training mission.



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*L. Peter Boice, Deputy Director of Natural Resources at the Department of Defense, can be reached at peter.boice@osd.mil.*

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**(Opposite page): L. Peter Boice visiting O'ahu, Hawaii.**

**(This page): Capt. Aaron Cudnohufsky, Commanding Officer, Pacific Missile Range Facility (PMRF), along with Dennis Rowley, Tom Clements, Don Heacock, and Bobby Ragassa, carry an injured green sea turtle (*Chelonia mydas*) to an all-terrain vehicle at Nohili Ditch on PMRF. The turtle was later transported to O'ahu for medical treatment and released back into the wild. Photo by MC2 Jay C. Pugh, U.S. Navy.**

# Defense Secretary Announces Environmental Awards

by Erica Evans and Kathryn Sabella

The Secretary of Defense recognizes the importance of defending our nation's natural resources to support the military training and testing mission. Each year since 1962, the Secretary has honored military installations, teams, and individuals for their outstanding achievements to sustain the natural and cultural resources entrusted to the Department of Defense (DoD). For 2010, DoD's Environment, Safety and Occupational Health Policy Board approved 17 awards within the categories of natural resources conservation, cultural resources management, environmental quality, pollution prevention, environmental restoration, and environmental excellence in weapon system acquisition.

The DoD environmental awards recognize small and large military installations, teams, and individuals that:

- promote natural resources conservation, including the identification, protection, and restoration of biological resources and habitats; the sound management and use of the land and its resources; and the promotion of the conservation ethic;
  - promote cultural resources management, including the identification, protection, and restoration of historical buildings and structures; archaeological sites; Native American tribes and Native Hawaiian sacred objects and sites;
  - and the promotion of the cultural resources ethic;
  - prevent or eliminate pollution at the source, including practices that increase efficiency and sustainability in the use of raw materials, energy, water, or other resources;
  - protect human health and the environment by cleaning up identified DoD sites in a timely, cost-efficient, and responsive manner; and
  - incorporate environmental, safety, and occupational health requirements into the weapon system acquisition program's decision-making process.
- The 2010 Environmental Award winners are:
- Fort Custer Training Center, Michigan Army National Guard: Natural Resources Conservation – Small Installation
  - Camp Guernsey, Wyoming Army National Guard: Cultural Resources Management – Installation
  - Marine Corps Base Hawaii: Environmental Quality – Non-industrial Installation
  - Fleet Readiness Center Southwest, California: Sustainability – Industrial Installation
  - Hill Air Force Base, Utah: Environmental Restoration – Installation
  - Mr. Stephen M. Seiber, Eglin Air Force Base, Florida: Natural Resources Conservation – Individual/Team
  - Mr. Awni M. Almasri, Naval Facilities Engineering Command Europe Africa Southwest Asia: Environmental Quality – Individual/Team
  - Ms. Regina Dixon Butler, Patrick Air Force Base, Florida: Environmental Restoration – Individual/Team
  - Aeronautical Systems Center Environmental and Occupational Health Team, Wright-Patterson Air Force Base, Ohio: Environmental Excellence in Weapons Systems Acquisition – Team

Each year, a growing number of outstanding nominees present their work for consideration. These awards acknowledge some of the premier environmental projects that DoD supports. For more information on DoD's award winning environmental efforts, visit <http://www.denix.osd.mil/awards/>.

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*Erica Evans, with the consulting firm Booz Allen Hamilton, can be reached at [evans\\_eric@bah.com](mailto:evans_eric@bah.com), and Kathryn Sabella, also with Booz Allen Hamilton, can be contacted at [sabella\\_kathryn@bah.com](mailto:sabella_kathryn@bah.com).*

# National Public Lands Day

## Engaging Volunteers in Natural Resources Conservation

by Jane Mallory

Since 1991, the Department of Defense (DoD) has participated in National Public Lands Day (NPLD), an annual event that brings volunteers and public land managers together to work for the restoration, conservation, and protection of essential natural resources. With the help of thousands of on- and off-post volunteers since 1999, and with funding from the DoD Legacy Resource Management Program, more than 320 individual projects throughout the country, and on Kwajalein Atoll and Guam in the Pacific, have benefitted military base environments.

The DoD Legacy Resource Management Program provides supplies for NPLD

projects, and teams of volunteers provide the labor. Throughout the years, they have worked together on a variety of projects: building bat boxes, bee condos, and bird houses; pulling invasive plants; planting native species; creating pollinator gardens; and clearing trash. Whether it is work that benefits a specific sensitive species (such as clearing debris from desert tortoise habitat on the Marine Corps Logistics Base in Barstow, California) or improving landscapes to benefit multiple species (such as planting healthy native trees, shrubs, and forbs on Greenbury Point at the Naval Academy in Annapolis, Maryland), the annual NPLD events prove that a little hard work from volunteers can go a

long way toward conserving species and habitat under DoD stewardship.

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*Jane Mallory (contracted support), a botanist working with the Department of Defense Legacy Resource Management Program, can be contacted at [Jane.Mallory.ctr@osd.mil](mailto:Jane.Mallory.ctr@osd.mil).*

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**Volunteers installing native plants and weeding invasive species to improve coastal marsh habitat on Naval Weapons Station, Seal Beach, CA.**

*Photo by Robert Schallmann.*



# Cooperative Conservation on the Puget Sound Prairies

## The Joint Base Lewis-McChord Army Compatible Use Buffer Program

by Hannah E. Anderson

**N**ative prairie habitat once occupied 150,000 acres (60,000 hectares) in the southern Puget Lowland of western Washington State. Ninety percent of this habitat has disappeared or been ecologically degraded. Human uses incompatible with conservation, along with the suppression of fire across the landscape, threaten the remaining prairies. Conifers and non-native vegetation are encroaching on the once open ecosystem.

A variety of rare species rely on prairie habitat for survival. Among them are four that are candidates for listing under the Endangered Species Act (ESA): two rare butterflies - Taylor's checkerspot (*Euphydryas editha taylori*) and the Mardon skipper (*Polites mardon*) - the streaked horned lark (*Eremophila alpestris strigata*), and the Mazama pocket gopher (*Thomomys mazama*). The largest expanse and the highest quality prairie habitat in the region occurs on Joint Base Lewis-McChord (JBLM), a 91,000-acre (37,000-ha) military installation 40 miles (65 kilometers) south of Seattle, Washington. If any of these species were to become listed, the U.S. Fish and Wildlife Service could impose significant military training restrictions. A group of concerned partners in the south Puget Sound are working together to recover these

species and preclude the need to list them under the ESA.

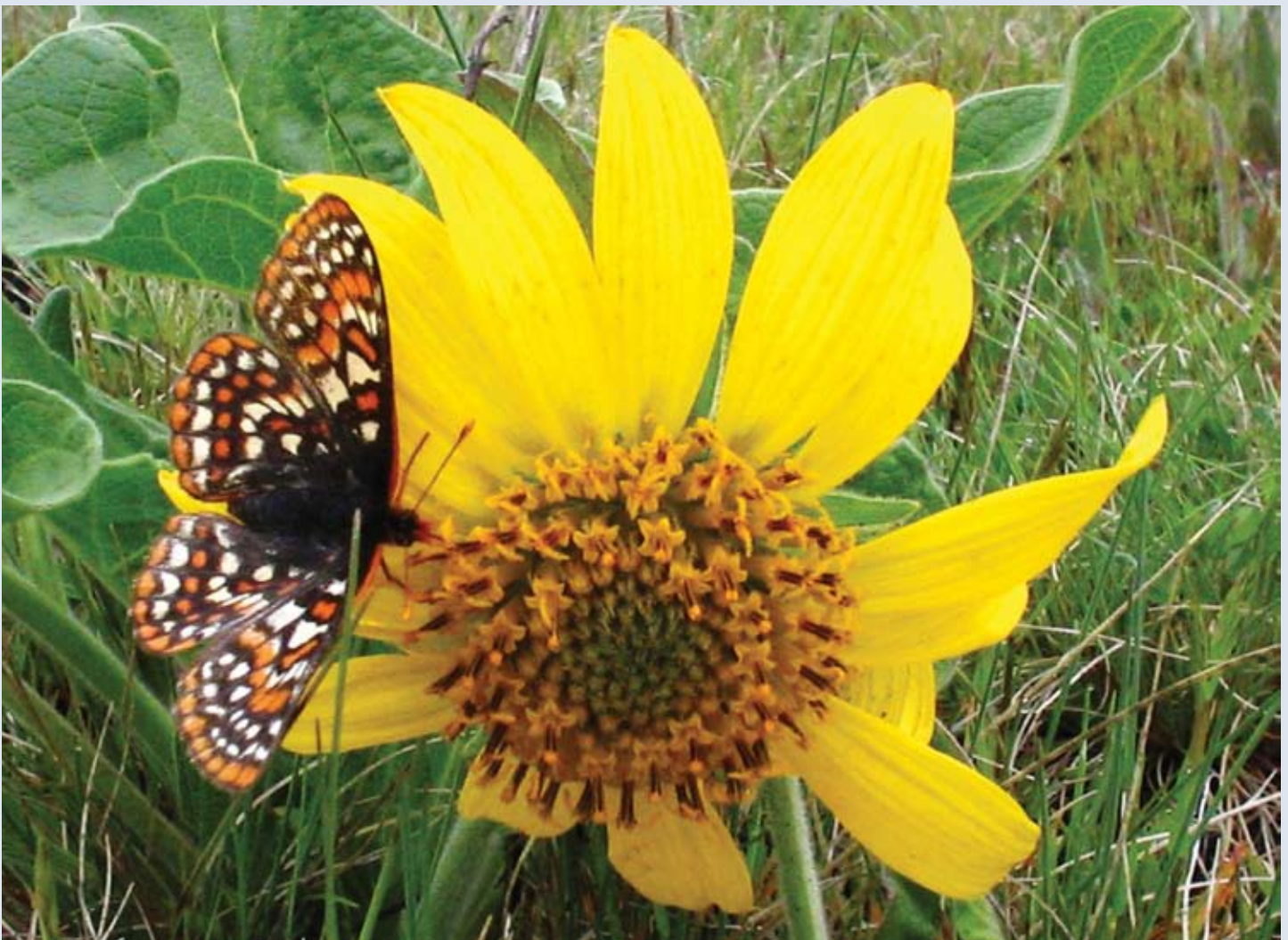
One significant conservation program in the region is the JBLM Army Compatible Use Buffer (ACUB) program. Most ACUB programs throughout the nation are geared towards acquiring and protecting land around military installations to serve as a buffer, which reduces the threat of "encroachment" (constraints on military training) due to incompatible development. The JBLM ACUB is different. In 2006, a team began using a cooperative approach to help sustain military readiness by implementing conservation actions for the four listing

candidates. The overall goal is to preclude the need to list or, if listing does occur, minimize the consequences.

The team does this through acquiring important prairie lands, restoring degraded habitats, and increasing the numbers and sizes of candidate species populations on the acquired lands. By supporting conservation actions on lands outside the base, the military shares the burden of recovery with the other ACUB partners: The Nature Conservancy, the Washington Departments of Fish & Wildlife and Natural Resources, and Wolf Haven International. The partners have acquired the prairie preserves and the







Department of Defense has provided essential funding support (\$3.3 million to date) for on-the-ground conservation actions.

The team is overcoming a common problem in conservation: insufficient resources for managing protected lands. In this case, management includes activities such as controlling invasive plants; using prescribed fire to restore historic natural ecological processes; growing, planting, and seeding native plants; breeding and reintroducing butterflies; reintroducing pocket gophers to ACUB properties; and planning, monitoring, and research.

Since the program's inception, the JBLM ACUB has acquired 1,025 acres (415 ha) of new conservation land, conducted ongoing restoration of these lands and 3,222 acres (1,303

ha) that were already in conservation status, and reintroduced Taylor's checkerspots and Mazama pocket gophers onto several ACUB properties. The team has answered significant questions about the target species, such as specific habitat requirements and predator identification. It has also conducted wall-to-wall vegetation mapping of all protected sites, information that has already been extremely useful for identifying new non-native species infestations and targeting areas for intensive habitat restoration. The JBLM ACUB projects have contributed significantly to the regional recovery of these rare native species.

The collaborative nature of the JBLM ACUB is one of the main strengths of the program. The partners agree that they accomplish much more

when working together rather than individually. Each entity is able to learn from the others, exchange information, and integrate its expertise into the collaborative effort. Most of the projects involve multiple years, sites, and partners. The goal is to promote continued military training, species recovery, open space protection, and the mutual respect and trust that come with cooperating toward a common purpose.

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*Hannah E. Anderson of The Nature Conservancy of Washington can be reached at [handerson@tnc.org](mailto:handerson@tnc.org).*

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**(Opposite page top): Streaked horned lark (*Eremophila alpestris strigata*).** Rod Gilbert.

**(Opposite page bottom): Managers prepare for a prescribed burn.** Photo by DoD.

**(This page): Taylor's checkerspot butterfly.**

Photo by Aaron Barna.

# Sustaining the Mission at Joint Base Lewis McChord

by David Clouse and Todd Zuchowski



At the Joint Base Lewis McChord (JBLM) in western Washington State, each of its major ecosystems -- late-successional forests, wetlands, and prairies -- provide unique opportunities to support both conservation and the military mission. In fact, projects to improve wildlife habitat frequently enhance military training opportunities. This makes it possible for managers to maintain viable populations of native flora and fauna, including listed species.

Natural resource personnel manage sites on military lands for the recovery of listed and federal candidate species, but they focus on areas of the installation that are compatible with

current and future uses of the area for training purposes. Compatibility is based on the requirements of the species targeted for augmentation and reintroduction. The following are examples from each of our ecosystems in which this process has been successful for both military training and species recovery.

Managing for late-successional forests on the military installation maintains overhead cover for training and a relatively open understory. This allows trainers to maneuver through the area and potentially enhances the site for the western gray squirrel (*Sciurus griseus*), a species of concern and a state threatened species. It also

creates habitat for nesting bald eagles. Since 1982, eagle nesting territories have increased from two to 10.

In addition to managing forests, natural resource managers at JBLM work to protect wetland habitats for various plant and fish species. Wetlands management focuses on controlling non-native plant species and protecting Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss*), and water howellia (*Howellia aquatilis*), an aquatic plant federally listed as threatened. A major management problem within wetlands and streams at JBLM is the spread of reed canary grass (*Phalaris arundinacea*). This



non-native grass species can completely choke off stream channels and displace other wetland plants. Sites that are overgrown with reed canary grass can lose their effectiveness for such military training uses as practice zones for airdrops.

Prairies in the Puget Sound region are the focus of yet another stewardship effort. They were once naturally maintained by periodic burning, but fires have been suppressed there for more than 100 years. As a result, trees and invasive species, such as the nonnative Scotch broom (*Cytisus scoparius*), have colonized prairie habitats. This shrub, which can grow up to 10 feet (3 meters) in height, significantly impedes military training and reduces habitat for prairie-dependent species. The Joint Base Lewis-McChord Fish and Wildlife program has responded by using prescribed burning, which benefits both the ecosystem and military training.

When present on a site, Scotch broom degrades open prairie habitat for four federal listing candidates. Eliminating this noxious shrub is the first step to recover a site's natural state, although efforts to restore habitats for native plants take place only on sites where the designated military use is compatible. By increasing the populations of rare species, we reduce



the likelihood of federal listing and significant impacts on military training. In some cases, limited disturbance of non-native ground cover can benefit a native species by recreating open habitat. Such is the case with the streaked horned lark (*Eremophila alpestris strigata*), which prefers some bare ground on which to locate its nests. Other species, such as the Taylor's checkerspot (*Euphydryas editha taylori*) butterfly, require nectar producing native plants and larval host plants, which grow on sites with limited ground disturbance, such as drop zones.

By focusing on a regional cooperative approach to natural resources management with partners such as the Nisqually Indian Tribe, Washington State Department of Fish and Wildlife, U.S. Fish and Wildlife Service, and The Nature Conservancy, JBLM is working to conserve rare species and prevent Endangered Species Act impacts on training. JBLM's use of sustainable programs, such as ecological burning, Taylor's checkerspot reintroduction, and Western gray

squirrel augmentation are now a cornerstone of management practices on the installation, and a model for the recovery of rare species on other military bases.

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*David Clouse, Joint Base Lewis-McChord Fish & Wildlife Program Manager, can be reached at david.c.clouse@us.army.mil or 253-967-3474. Todd Zuchowski, Joint Base Lewis-McChord Wildlife Biologist, can be reached at todd.zuchowski@us.army.mil or 253-966-6443.*

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**(Opposite page top): Taylor's checkerspot butterfly (*Euphydryas editha taylori*).** Photo by DoD.

**(Opposite page bottom): Muck Creek Channel filled with reed canary grass (*Phalaris arundinacea*) before and after mechanical removal enhancement.** Photo by Rod Gilbert.

**(This page top): Taylor's checkerspot.** Photo by Ted Thomas, USFWS.

**(This page bottom): Mazama pocket gopher (*Thomomys mazama*).** Photo by Rod Gilbert.



Photo by Rod Gilbert.

# Conservation Frontiers

## Plants Conservation on Military Lands and Beyond

by Bernd Blossey and Victoria Nuzzo

**H**undreds of plant species in the United States face extinction, despite significant efforts to protect these species and their habitats. Because plants are

often at the center of conservation actions for land managers at military installations, their declines are troubling and threats are often multifaceted, among them habitat loss and

fragmentation, the spread of invasive plants, animals, and diseases and climate change. Protecting the last remaining populations of rare plant species from extinction, re-building and restoring larger populations of these species, and preventing further decline of species currently at risk of extinction is paramount to conservation efforts.

With funding provided by the Strategic Environmental Research and Development Program (SERDP), a team of ecologists from the Department of Natural Resources at Cornell University is working to disentangle the effects of various threats, or stressors, that contribute to the rarity of four state-listed or vulnerable plant species in New York – beaked agrimony (*Agrimonia rostellata*), Virginia snakeroot (*Aristolochia serpentaria*), reflexed sedge (*Carex retroflexa*) and red trillium (*Trillium erectum*). The team conducts their work at West Point Military Academy (USMA), 50 miles (80 km) north of New York City in the Hudson Highlands ecoregion. Established in 1802, USMA is the oldest of five service academies in the United States. The site, which overlooks the Hudson River, boasts significant forested areas and wetlands, where the team is able to investigate different stressors including invasions by a number of European and Asian earthworms, particularly *Amyntas* and *Lumbricus* spp.; invasions by three plant species, garlic mustard (*Alliaria petiolata*), barberry (*Berberis thunbergii*), and Japanese stiltgrass (*Microstegium vimineum*); invasions by European slugs, mainly *Arion subfuscus*, and root weevils (*Barypeithes pellucidus*); nutrient loading through aerial deposition; and the impact of overabundant white-tailed deer (*Odocoileus virginianus*).

This work is conducted in multiple venues: large (30x30 m) deer exclosures erected at USMA paired with similar-sized unfenced control areas,



experimental plantings and seedlings to assess potential restoration techniques, and a variety of common garden and laboratory experiments to tease apart the contribution of individual and combined stressors on demography of the four state-listed plant species. The team selected the target plant species not only for their status as regionally listed species, but also for their assumed different vulnerability to earthworm invasions, or deer herbivory.

Based on the results of previous research, the team assumed deer herbivory and earthworm invasions would overwhelm the importance of other stressors in the demise of these rare target plant species. In an attempt to assess deer browse intensity at the various field sites, the team employs a sentinel approach using 3-month old oak seedlings. The team monitors these oak seedlings, along with individually marked specimens of the target native plant species growing inside and outside of deer exclosures, for their survival, growth, and deer browse intensity.

After only 2 years of field observation, the team's results show that deer herbivory on oak seedlings and three of the four 'rare' plant species is excessive, and considerably reduces growth, flowering, and fruiting. This is further increasing concerns for long-term survival of rare browse-sensitive species.

Work by other scientists demonstrates that for the closely related white trillium (*Trillium grandiflorum*), browse intensity exceeding 15 percent of reproductive individuals leads to

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**(Opposite page): Virginia snakeroot.**

**(This page top): West Point oak seedling.**

**(This page bottom): Red trillium.** Photos by Bernd Blossey.



long-term population decline. Unlike individuals exposed to deer, individuals of the listed plant species growing inside exclosures show strong signs of recovery, and the taller, more robust plants bear little resemblance to the tiny individuals initially encountered. In the absence of deer herbivory, native plants are better able to stand their ground against invasive plants, at least against the three invasive plants that the team monitors in eastern deciduous forests.

Managers often blame invasive plants for deteriorating native plant communities, but the team's work indicates it is a complex of stressors responsible for this degradation. The results of this research, although preliminary, point to the overwhelming

importance of deer herbivory in the decline of many plant species in eastern forests. Conservation efforts, particularly managing invasive plant species in preserves or on military installations, should focus on the source of degradation to prevent further decline. Merely removing invasive plant species will not achieve the same level of conservation benefits for state and federally listed browse sensitive plant species as reducing overabundant deer herds across much of North America would.

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**(Inset): A good example of rich groundlayer vegetation protected from deer herbivory.**

*Photo by Victoria Nuzzo.*

**(Opposite page): Deer exclosure.**

*Photo by Bernd Blossey.*





# Banking Seeds for the Future

## An Essential Tool for Plant Recovery

by Jane Mallory



Department of Defense (DoD)-managed lands contain habitats that support 186 plant species that are listed under the Endangered Species Act or are candidates for listing. Because listed species on DoD lands can lead to restrictions on training and operations, working towards species recovery whenever possible benefits not only the species but also installation operations and the military mission. To conserve these rare species, the DoD Legacy Resource Management Program enlisted the assistance of the Center for Plant Conservation, a non-profit network of institutions dedicated to conserving and restoring America's native plants.

According to the Center, a number of recovery plans for federally-listed plants propose the reintroduction of nursery-grown stock as one way to increase wild populations to a sustainable level. Such reintroductions originate from *ex-situ* (off-site) collections of plant cuttings, seeds, spores, and/or tissue cultures. However, existing collections are distributed widely among many institutions, and there was no public database on the amount, condition, and age of material potentially available for restoration work. The DoD Legacy Program addressed this problem by funding the Center to conduct a comprehensive study on the state of *ex-situ* material for all DoD-protected plant species.

The Center's report provides detailed information for each species, a description of *ex-situ* material and the collection sites, and identifies species that lack such material. DoD installations and the military services can use this information to examine efforts to secure the genome of vulnerable plant species and improve the potential for any future reintroductions. For example, the study revealed that 130 of the





186 imperiled plant species found on DoD lands lack any DoD site-specific collections. They also found that *ex-situ* material for 61 of the 186 species had never been collected and stored anywhere, possibly hindering recovery efforts and leaving these species particularly vulnerable to extinction.

In 2010, the DoD Legacy Program awarded the Center additional funding to use the study results as a guide for the next DoD endeavor, the “Seed Banking Federally-listed Mainland Plant Species on DoD Lands” project. This is a multi-year effort to collect seeds and other material from species found on DoD mainland installations. Field biologists from the Center and its partner institutions, such as botanical gardens, arboreta, and universities, are now working with natural resource managers at military installations to collect material for the 20 highest priority species and will collect additional species in the coming year. Scientists will store collection information in the Center’s central database to track various attributes (propagule counts, age, location, etc) of *ex-situ* material for future research

and restoration work. They will store the actual seeds and cuttings at the U.S. Department of Agriculture’s National Center for Genetic Resources Preservation in Ft. Collins, Colorado. This effort will secure DoD site-specific wild-collected seed for the most vulnerable species and help safeguard the genetic integrity of declining populations. This research can be used to provide a seed bank resource for immediate and future restoration needs and create a safety net against unforeseen threats to wild populations. These seed collections could also be used for additional research tasks identified in recovery plans and serve as a source material for possible out-planting efforts by DoD natural resources managers.

In addition to collecting data and material that could one day help recover rare plants on military installations, DoD is also providing training for its natural resources managers in topics that relate specifically to plant conservation. In 2007, the Center used funding from the DoD Legacy Program to tailor their plant conservation training course for

DoD managers and presented it during a workshop in Honolulu, Hawaii, an area that supports the lion’s share of imperiled plants in the United States. Thirty DoD personnel, state agency personnel, DoD contracted support, and partners attended this workshop. Over the course of six days, nine PhD faculty members taught 17 different topics, such as Concepts of Rarity and Imperiled Plants, Importance of Systematics, Population Evaluation using Demography Population Viability Analysis, and Recovery Criteria. The course was such a success that the Center presented it again in 2009 in California, and is hoping for a third offering in North Carolina in the near future.

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**(Opposite page): Ute ladies'-tresses (*Spiranthes diluvialis*).** Photo by Bekee Hotze, USFWS.

**(This page): Golden paintbrush (*Castilleja levisecta*).** Photo by Ted Thomas, USFWS.

# Connecting Landscapes for Biodiversity

## Habitat Conservation On and Around DoD Lands

by Aaron Moody

**H**abitat fragmentation due to land-use changes near military bases poses major challenges for wildlife conservation on Department of Defense (DoD) lands. Fragmentation isolates species populations, thereby increasing their exposure to risks from demographic, genetic, and environmental factors (Gilpin and Soule 1986). This potentially undermines the wildlife recovery efforts on installations by DoD land managers.

Fort Bragg, situated in the Sandhills ecoregion of North Carolina, is emblematic of this situation. One of the largest and most active U.S. military bases, Ft. Bragg is an island of nearly intact forest surrounded by agriculture and development. As a result of fire management that mimics natural processes, Fort Bragg contains some of the most extensive high-quality long-leaf pine habitat for the endangered red-cockaded woodpecker (*Picoides borealis*). It fully encompasses the known range of an endangered butterfly, the Saint Francis' satyr (*Neonympha mitchellii francisci*). Fort Bragg also is home to three other endangered species and approximately 70 species of concern. Our research team is working on behalf of DoD's Strategic Environmental Research and Development Program to determine how to conserve habitat connectivity between on- and off-base habitats where multiple species must be managed simultaneously, while also



The Saint Francis' satyr survives only on Fort Bragg.

accommodating the base's military readiness mission.

One approach to offsetting the isolating effects of fragmentation is to preserve connections among protected habitats (Beier & Noss 1998, Tewksbury et al. 2002). The DoD has accelerated land acquisition around some bases to enhance connectivity among existing habitats for rare species (Herring 2004). However, identifying the best

lands to preserve is challenging, especially for multiple species that vary in their abilities to disperse through different natural, managed, or developed habitats (Ricketts 2001).

Historically, lands have been selected using expert opinion on a species-by-species basis (Beier et al. 2009). More recently, computational approaches have been developed to reduce subjectivity and automate the process of quantifying the value of land for habitat connectivity (Calabrese and Fagan 2005). For most species, these approaches are limited by a lack of information about how landscape features affect movement behavior and by the persistence of a single-species focus for connectivity assessment.

Study species include not only the red-cockaded woodpecker and Saint Francis' satyr but also two amphibian species, the eastern tiger salamander (*Ambystoma tigrinum tigrinum*) and Carolina gopher frog (*Rana capito capito*), both of which are listed by North Carolina as threatened at the state level. The team collected detailed data on movement behavior for these species using multiple methods, including radio-telemetry, *in-situ* (on site) observations, experimental releases of captive-bred animals and translocated animals into different landscape types and at landscape boundaries, tracking movement paths using fluorescent dye powder, and pit-trapping for amphibians near

breeding ponds. The team is linking these data with detailed environmental maps derived from field data, satellite remote sensing, and aircraft-based light detection and range (LiDAR), which uses a laser pulse return to map the 3-D structure of the land surface, to understand how different landscape features affect animal movement and dispersal and to map habitat connectivity. The goal is to provide information on the habitat connectivity value of each land parcel that might be acquired for conservation.

The team developed statistical models of habitat connectivity for the red-cockaded woodpecker by using radio-telemetry data from dispersing juvenile females as they searched for breeding sites. Dispersing birds avoided open and developed areas and preferred to disperse through forested landscapes, including forest types that are not used for nesting. The research team used the data to measure the relative resistance of the landscape to dispersal and to map those lands that promote dispersal.

For the Saint Francis' satyr, models of habitat connectivity are based on the simulated dispersal of butterflies through a virtual representation of Fort Bragg and surrounding landscapes. The simulation is based on movement behaviors observed from butterflies in their natural habitats and butterflies experimentally translocated and released into different types of natural and developed habitats. To map habitat connectivity, the team recorded the frequency with which simulated butterflies passed through each grid cell in the virtual landscape. Interestingly, butterflies make longer, straighter movements in upland forests, suggesting that this may be important dispersal habitat. Butterfly behavior at riparian forest edges indicated that these lands also function as dispersal corridors. In contrast, because butterflies rarely enter large

open areas, these habitats may serve as dispersal barriers.

To streamline the process of developing and integrating connectivity models, the team developed a user-friendly software package called "CONNECT" that operates seamlessly with mainstream geographic information software (ESRI ArcGIS 9.3). CONNECT combines habitat data and resistance surfaces (maps that depict how difficult it is for animals to move through the landscape) to generate likely dispersal corridors and habitat networks. CONNECT also allows combining connectivity models for multiple species to identify the highest value locations for multi-species connectivity. CONNECT makes it easy for users to incorporate animal movement models into larger work flows and to explore the affects of alternate land management, conservation, and restoration scenarios on regional-scale habitat connectivity for wildlife conservation.

Our research team is using data, models, and CONNECT to address questions relevant to wildlife conservation on and around DoD installations. The Sandhills Conservation Partnership, a multiple-stakeholder group that coordinates conservation activities in the Sandhills ecoregion, can use the information and methods developed through this project to set land acquisition priorities in order to benefit both the base and the fauna and flora of the region.

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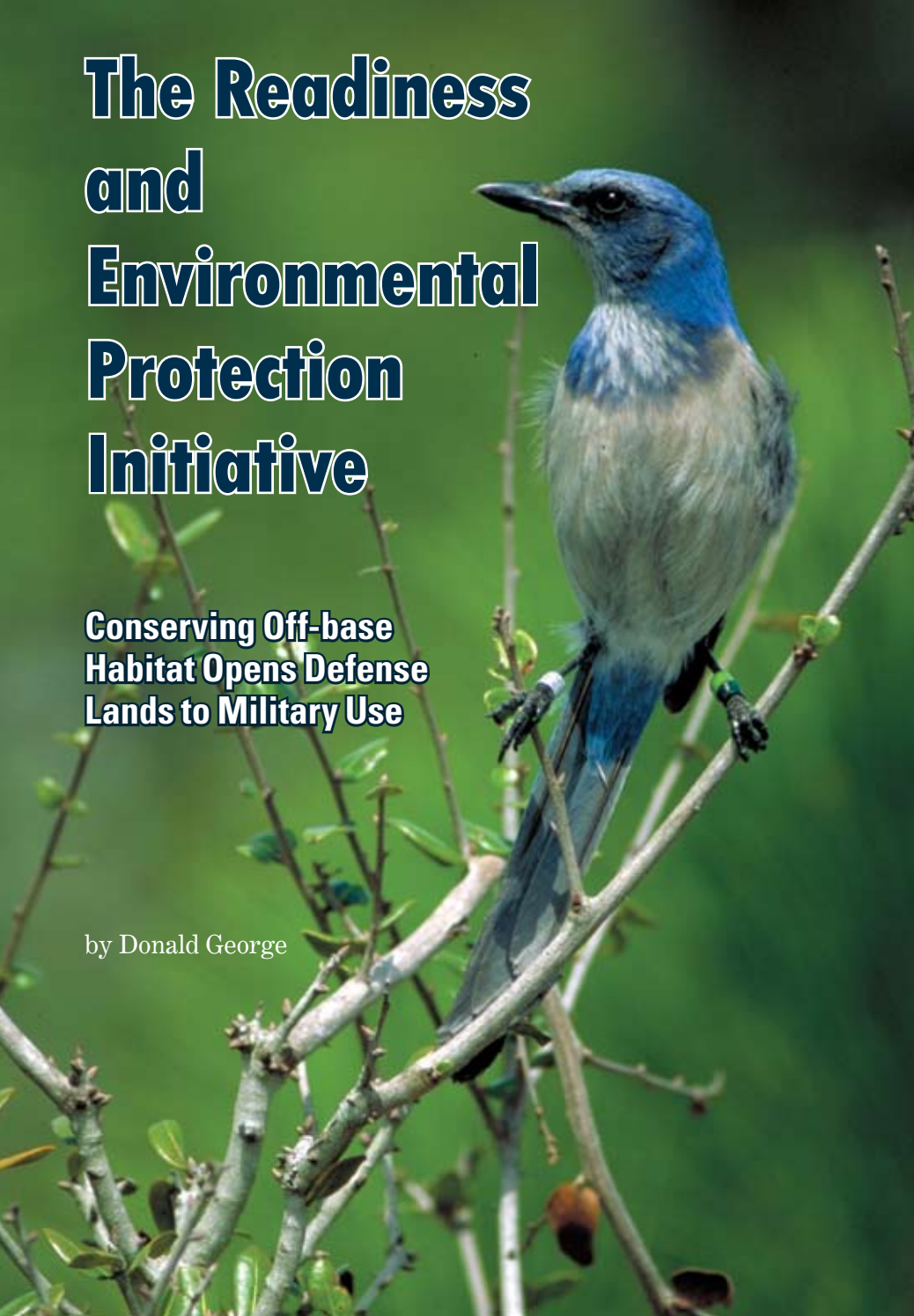
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*Aaron Moody, Department of Geography & Curriculum for the Environment and Ecology, University of North Carolina, Chapel Hill, can be contacted at aaronm@email.unc.edu or 919-962-5303.*

# The Readiness and Environmental Protection Initiative

## Conserving Off-base Habitat Opens Defense Lands to Military Use

by Donald George



One of the core purposes of the U.S. Department of Defense's (DoD) Readiness and Environmental Protection Initiative (REPI) projects is to conserve such environmental assets as wildlife in a manner that supports military mission readiness and national security. These projects also demonstrate a commitment to landscape-level planning, which helps preserve biodiversity, allows

for species migration, and provides greater opportunities for adapting to, and mitigating, the effects of climate change.

When threatened and endangered species are present on installation habitat, training can be severely restricted. To alleviate this problem, installations are working with an off-post local conservation entity to promote the recovery of listed species

and conserve their habitat on lands off the military base. Installations can accrue credits and alleviate restrictions by contributing to a species' recovery on these non-DoD lands. Similarly, installations can receive credits for protecting off-post habitat, which can be applied to mitigate construction or other on-post habitat uses.

While a number of REPI projects have preserved valuable habitats and allowed DoD missions to continue, the project at Cape Canaveral Air Force Station in Florida illustrates the mutually beneficial relationship between species conservation and DoD's readiness efforts.

Cape Canaveral Air Force Station is the only U.S. space launch site capable of placing satellites into geosynchronous orbit (an orbit that places a satellite stationary over a given spot). Both government and commercial space operations rely heavily on Cape Canaveral's launch capability. However, because Cape Canaveral AFS is a critical conservation area for the threatened Florida scrub-jay (*Apelocoma coerulescens*), current launch programs are confined to their existing footprints to prevent loss of scrub habitat. The only available land for any new "heavy" launch vehicle or processing facilities is mostly scrub jay habitat, and all activities that impact scrub habitat on the base incur a 4:1 mitigation requirement to offset the habitat loss.

Since the Station is only 15,800 acres (about 6,395 hectares) and surrounded on three sides by water, the land available for new facilities is limited. Cape Canaveral has only 8,000 acres (3,240 ha) of undeveloped lands remaining, with 2,000 acres (8,000 ha) acres of that land currently set aside for conservation as a result of endangered species consultations with the U.S. Fish and Wildlife Service (FWS). Based on the offset



requirements, only 1,200 acres (500 ha) on the base remain available for military mission use.

To protect its military mission and conserve habitat, Cape Canaveral partnered with Brevard County and its voter-approved Environmentally Endangered Lands Program to preserve nearby undeveloped scrub habitat. The County acquired 188 acres (76 ha) of scrub habitat, and the Air Force received a conservation easement on 101 acres (40 ha) of that parcel. This project will help protect the survival of the Florida scrub-jay and, in working with the FWS, Cape Canaveral may receive Recovery Credits to alleviate future mitigation requirements when mission development exceeds the 1,250-acre level. This first

successful REPI project in Air Force Space Command will allow continued launches of satellites to support GPS, communications, and weather forecasting for the entire nation.

In another example of the REPI program, Camp Bullis Military Training Reservation in Texas will protect off-post habitat to support the recovery of the golden-cheeked warbler (*Dendroica chrysoparia*). Through a consultation with the FWS under section 7 of the Endangered Species Act, Camp Bullis will be able to clear unoccupied warbler habitat on post for medic field training, which is its primary training mission. Warbler habitat conserved off-post will mitigate for the on-post loss. This innovative use of REPI as a new tool

for alleviating training restrictions is being closely inspected as a model for other installations. Lessons learned from the Army's efforts at Camp Bullis will help a number of other installations currently discussing recovery efforts with the FWS, such as Marine Corps Base Camp Lejeune.

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*Donald George, U.S. Air Force, can be contacted at [donald.george@patrick.af.mil](mailto:donald.george@patrick.af.mil) or 321-853-6823.*

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**(Opposite page): Florida scrub jay.**

*Photo by Thomas G. Barnes.*

**(This page): Golden-checked warbler.**

*Photo by Gil Eckrich.*

# Partnerships from Hawaii to North Carolina

## The Readiness and Environmental Protection Initiative

by Nancy Natoli



**T**he U.S. Department of Defense's (DoD) Readiness and Environmental Protection Initiative (REPI) supports public-private conservation partnerships that work on a cost-share basis. These mutually beneficial partnerships succeed when a partner's focus area includes habitat for endangered species regulated on nearby military lands, or when partners are interested in areas where open space is important to maintaining the military's ability to test and train nearby. REPI's purpose is to sustain the military mission by proactively conserving the landscape and natural infrastructure beyond DoD owned land. For six years, this initiative has helped protect threatened and endangered species and their habitat across the country.

### Hawaii

A biological opinion resulting from endangered species consultation with the U.S. Fish and Wildlife Service (FWS) requires the Army to manage 75 pairs of 'elepaio (*Chasiempis sandwichensis ibidis*), a small bird native to Hawaii that inhabits DoD land. REPI funding supports the permanent protection of 'elepaio habitat at the Honouliuli Preserve and Moanalua Valley on the island of O'ahu. The U.S. Army Garrison Hawaii has a cooperative agreement with the Trust

for Public Land to protect the two locations.

The Trust for Public Land supports the Army with aggressive land management of these parcels, assisted by a large coalition of other partners including the FWS, the City and County of Honolulu, the Office of Hawaiian Affairs, and the Hawaii Department of Land and Natural Resources. Together, these organizations protect endangered species habitat from development, and have conserved an additional 3,004 acres (1,215 hectares) of open space adjacent to DoD lands.

### California

Camp Pendleton, a Marine Corps training base in Southern California, is the largest oasis of undeveloped coastal open space between Los Angeles and San Diego. It is also home to 14 threatened and endangered animal species including San Diego fairy shrimp (*Branchinecta sandiegonensis*), Riverside fairy shrimp (*Streptocephalus wootori*), arroyo southwestern toad (*Bufo californicus microscaphus*), steelhead salmon (*Oncorhynchus mykiss*), tidewater goby (*Eucyclogobius newberry*), Stephens' kangaroo rat (*Dipodomys stephensi*), Pacific pocket mouse (*Perognathus longimembris pacificus*), and seven species of birds.

Camp Pendleton's conservation efforts involving REPI aim to create and maintain linkages between San Diego County's North County Multiple Species Conservation Plan, California's Santa Ana-Palomar Mountains Linkage Conceptual Area Protection Plan, and the Mount Olympic Magee Ridge Reserve Conceptual Area Protection Plan. In addition to working with these conservation efforts, Camp Pendleton has partnered with the Trust for Public Land and San Diego County to pool more than \$4 million to conserve nearly 1,300 acres (526 ha) of wildlife habitat.

### North Carolina

In the late 1990s, training activities at Fort Bragg—one of the most combat-ready and active military installations in the country—were heavily restricted due to the presence of the endangered red-cockaded woodpecker (*Picoides borealis*). In 2000, the Army and The Nature Conservancy initiated an unconventional partnership to protect habitat for the species on private lands. Thanks to this partnership, the FWS and the Army can now celebrate having met their goal of recovering 350 potential breeding groups of woodpeckers in the Sandhills East Recovery unit, a core recovery area for the species. In fact, this goal was achieved in 2006, five years earlier than anticipated. Fort Bragg's success served as the model Congress used for

creating the enabling legislation that is now the foundation for REPI.

Integrating DoD's conservation of endangered species into a larger landscape through REPI allows the agency to use its own real estate more effectively to support the current and future military mission. Conserving endangered species both on and near military lands across the country is a mission enabler.

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*Nancy Natoli, the Department of Defense Readiness and Environmental Protection Initiative Coordinator, can be reached at [nancy.natoli@osd.mil](mailto:nancy.natoli@osd.mil) or 703-604-1820.*

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**(Opposite page): O'ahu elepaio.**

*Photo by Eric Vander Werf of Pacific Rim Conservation.*

**(This page): Longleaf pine (*Pinus palustris*).**

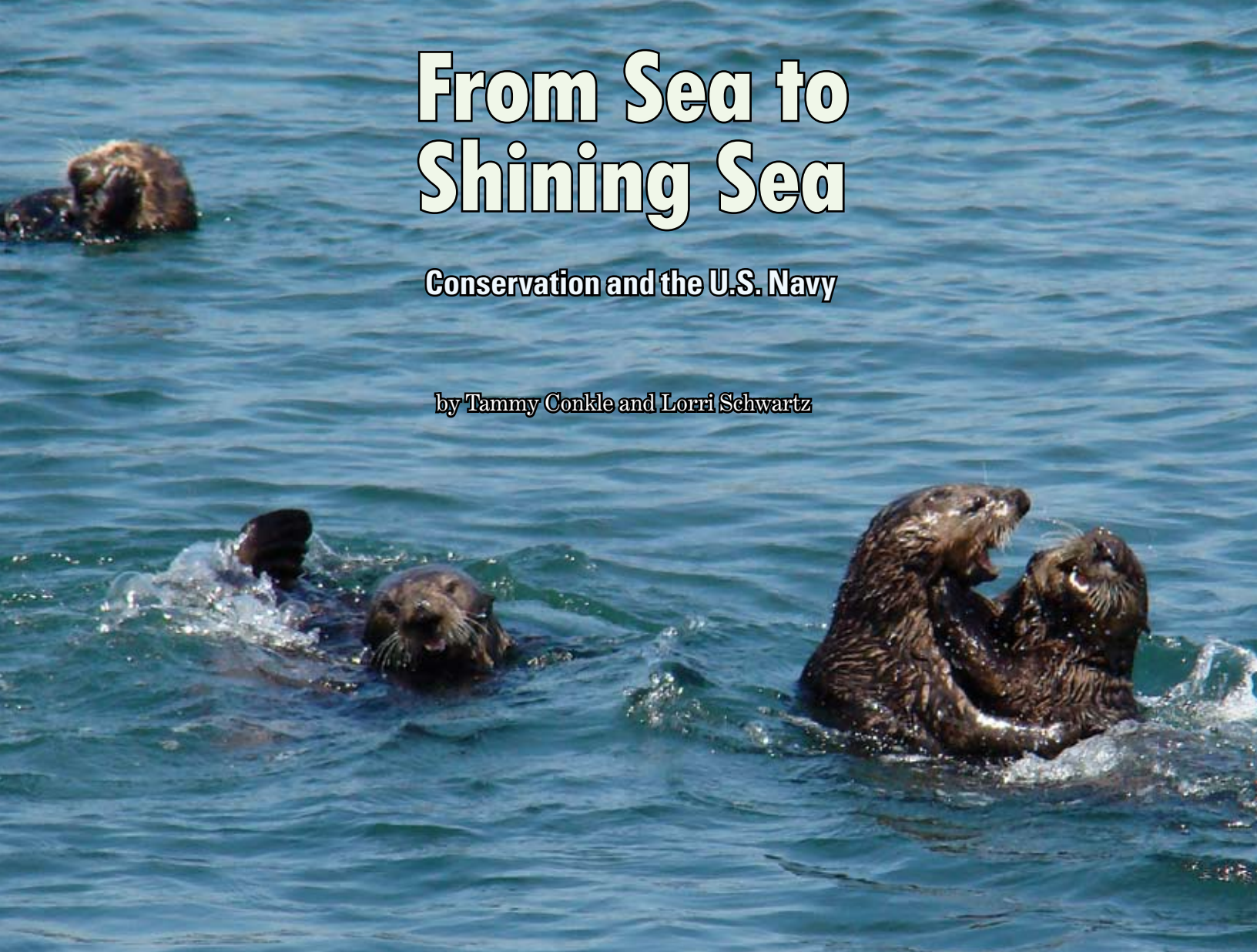
*Photo by the Department of Defense Military Services.*



# From Sea to Shining Sea

## Conservation and the U.S. Navy

by Tammy Conkle and Lorri Schwartz



The U.S. Navy strives to be a good steward of the environment while carrying out its primary mission of national security at sea. On its bases, which encompass 2.1 million acres (0.8 million hectares) of land, and in surrounding areas, the Navy manages ecosystems that support more than 100 federally listed species. These lands are distributed across seven “Navy regions” in the United States.

Many of the Navy’s conservation successes stem from using ecosystem principles as the foundation of its Integrated Natural Resources Management Plans (INRMPs). INRMPs are designed to ensure that

species populations can thrive while ensuring that there is a no net loss to critical training and operations. The following examples from the Pacific Southwest and along the Atlantic Coast illustrate some of the Navy’s successful INRMP-driven conservation programs.

### Flagship Efforts in the Pacific Southwest

Navy lands in the Southwest contain some of the nation’s most diverse ecosystems in terms of plant and wildlife communities. Due to massive growth and urbanization, Navy lands have become some of the last remaining islands of biodiversity within a sea of development. In

cooperation with the U.S. Fish and Wildlife Service, the Navy’s coastal and inland installations in this region work to conserve more than 40 federally listed species. Two island ecosystems, San Clemente Island (SCI) and San Nicolas Island (SNI), highlight the Navy’s efforts. SCI has the highest number of endemic species of all the California Channel Islands. It is part of the southern California Range Complex, a Navy range that supports simultaneous ship to shore, air to ground, and ground troop training. The Navy’s natural resources programs have dramatically benefitted the San Clemente loggerhead shrike (*Lanius ludovicianus mearnsi*), once considered the most endangered bird



in North America. Its numbers have increased from a low of 13 to about 300. Six of the island's listed plants are also showing trends toward recovery.

San Nicolas Island supports research, development, testing, and evaluation of air weapons and associated aircraft systems while managing two federally listed species and four marine mammals. Some of California's threatened southern sea otters (*Enhydra lutris nereis*) were translocated from coastal waters to SNI several decades ago to create a separate population in case the main population is struck by a catastrophic oil spill or disease event. The SNI population now numbers 30 to 40 adults. Our management programs at both SCI and SNI have prevented the need for federal listing of island fox (*Urocyon littoralis*) subspecies on Navy islands and has also supported a request for delisting of the island night

lizard (*Xantusia riversiana*) due to recovery.

Mainland resources found on Naval Base Coronado, Naval Base Ventura County, and Naval Weapons Station Seal Beach are key contributors toward the recovery of the California least tern (*Sterna antillarum browni*). This bird's nesting numbers have dramatically increased in conjunction with management programs began in the early 1980s. In addition, management of beach and dune ecosystems as well as coastal marshes on many Navy installations has proven effective for the western snowy plover (*Charadrius alexandrinus nivosus*), salt marsh bird's-beak (*Cordylanthus maritimus* ssp. *maritimus*), and light-footed clapper rail (*Rallus longirostris levipes*). Our management of inland ecosystems, including coastal sage scrub and riparian areas, has benefited the Quino checkerspot butterfly

(*Euphydryas editha quino*), arroyo toad (*Bufo californicus*), coastal California gnatcatcher (*Polioptila californica californica*), least Bell's vireo (*Vireo bellii pusillus*), and Stephens' kangaroo rat (*Dipodomys stephensi*). The last four of these species are managed in concert with the Navy munitions storage mission at Detachment Fallbrook.

### The Tortoise and the Hare

Installations in the Navy's Southeast region encompass more than 130,000 acres (52,609 ha) across seven states and Cuba (Naval Station Guantanamo Bay Cuba). These properties support

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**(Opposite page):** The threatened California sea otter is one of the rare animals found in Navy-managed waters. Photo by Lillian Carswell, USFWS.

**(This page):** The gopher tortoise depends at least in part on Navy lands in the Southeast. Photo by U.S. Navy.





habitat for more than 30 federally-listed species and other state-listed species. The unique plants and animals range from delicate flowers to huge whales, from Caribbean corals to ancient cactus plants, and from the gopher tortoise (*Gopherus polyphemus*) to the lower keys marsh rabbit (*Sylvilagus palustris hefneri*). For many of these species, Navy properties contain some of the last vestiges of their habitat. In addition to our own management efforts, partnerships (such as Southeast Regional Partnership for Planning and Sustainability) allow the Navy to collaborate with other interests on the recovery of listed species while supporting its military mission.

Many of the Navy's efforts in the Southeast focus on range-wide conservation and management, specifically in the native longleaf pine ecosystem. Listed species such as the endangered reticulated flatwoods salamander (*Ambystoma bishopi*), Mississippi gopher frog (*Rana capito*), and eastern indigo snake (*Drymarchon corais couperi*), as well as keystone species like the gopher tortoise, depend on this ecosystem. On Naval Air Station Whiting Field's Outlying Landing Field Holley, a cooperative effort with the U.S. Fish and Wildlife Service allowed habitat managers to conduct a prescribed burn, which benefits fire-adapted species like the salamander. The effectiveness of restoring fire to the longleaf forest was demonstrated by the discovery of a gravid (pregnant) adult female flatwoods salamander where no individuals had been documented in 12 years.



A significant portion of the lower keys marsh rabbit population can be found on Naval Air Station Key West. Navy ecosystem management strategies focus on eliminating invasive plant species, restoring native plants,

prescribed burning, and predator control.

The Navy's management efforts often encompass estuarine and near-shore environments. The West Indian manatee (*Trichechus manatus*) is an endangered species that can be found at several Navy installations in coastal waters of Georgia and Florida. The Navy program centers on methods to avoid manatees, such as the use of no-wake zones, manatee lookouts, manatee sightings reporting, and elimination of such human-caused attractants as freshwater discharges.

For additional information about the Navy's natural resources programs, as well as news about energy and environmental initiatives, we invite you to explore *Currents*, the Navy's environmental magazine. It can be found online at <http://www.enviro-navair.navy.mil/currents.cfm>, or by visiting the Navy's energy, environment, and climate change website at <http://greenfleet.dodlive.mil>.

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*For more information please contact Tammy Conkle, with the Navy Installations Command in Washington, D.C., at [tamara.conkle@navy.mil](mailto:tamara.conkle@navy.mil) or 202-433-4482. Lorri Schwartz, a natural resources specialist with the Naval Facilities Engineering Command Headquarters in Washington, D.C., can be reached at [Lorri.A.Schwartz@us.army.mil](mailto:Lorri.A.Schwartz@us.army.mil).*

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**(Opposite page top): San Clemente loggerhead shrike.**

**(Opposite page bottom): Lower Keys marsh rabbit.**

**(This page top): Prescribed fire at OLF Field Holley maintains habitat for species that depend on long-leaf pine forest.**

**(This page bottom): Reticulated flatwoods salamander.** *Photos by U.S. Navy.*



# The Proof of Sea-level Rise is in the Plover

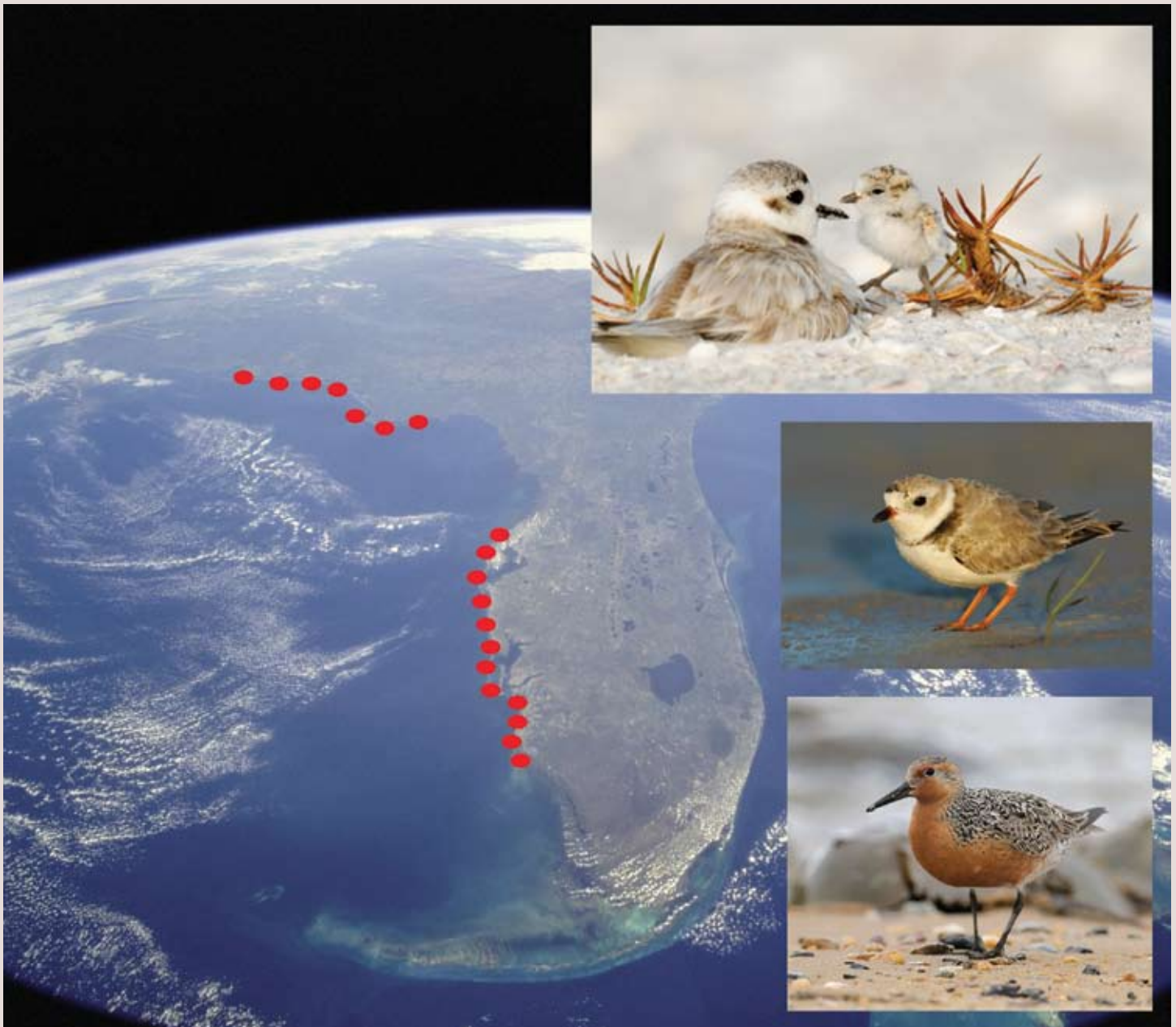
## Climate Change and Shorebirds in Florida

by I. Linkov, R. Fischer, M. Convertino, M. Chu-Agor, G. Kiker, C.J. Martinez, R. Muñoz-Carpena, H.R. Akçakaya, and M. Aiello-Lammens

Many of Florida's military installations are near sizeable coastal barrier islands that provide habitat for many shoreline-

dependent bird species. Potential land-cover and terrain changes, coupled with uncertain predictions for sea-level rise and increases in storm

frequency and intensity, pose difficult management challenges for natural resource managers.



For example, Eglin Air Force Base and Tyndall Air Force Base maintain coastal areas that provide breeding and wintering habitats for the snowy plover (*Charadrius alexandrinus nivosus*), wintering habitat for the piping plover (*Charadrius melodus*), and migratory stopover habitat for the red knot (*Calidris canutus*). Unfortunately, all three species are imperiled at the state or national scales, making any changes in habitat a matter of importance from both a policy and conservation perspective. The limited human disturbance at these military sites, along with the conservation of other habitats on parcels of shoreline managed by the National Park Service and the state of Florida, are major factors contributing to the survival of these species. All three require

high-quality intertidal and near-shore habitats for foraging. The snowy plover also needs undisturbed beach and dune habitat for nesting.

The main use of coastal beaches on military installations is to provide realistic training areas for the U.S. Armed Forces. For example, the barrier island habitat on Eglin Air Force Base is being assessed for future engineering projects (e.g., access road armoring, dune rebuilding, shoreline nourishment to protect infrastructure and maintain training sites, and creation of seawalls and bulkheads) to maintain suitable conditions for training. Land and facility managers must meet this primary military mission while conserving natural resources to the extent possible and to

balance multiple, potentially-conflicting objectives.

The U.S. Department of Defense's (DoD) Strategic Environmental Research and Development Program provided funding to the U.S. Army Engineer Research and Development Center, University of Florida,

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**(Facing page, background image):** The distribution of the snowy plover breeding/nesting areas (red dots) in Florida. A snowy plover male and a fledgling is at the top-right corner, a piping plover is below, and a red knot is at the left-bottom. *Photos by NASA and USFWS.*

**(Below):** Favorable nesting habitat for the snowy plover: forefront dune areas comprised of fine white sand and scattered debris at East Santa Rosa Island, Florida. A snowy plover nest is shown in the inset. *Photos by M. Convertino and R.A. Fischer.*



State University of New York, and Applied Biomathematics (a research and software company) to build an interdisciplinary team. The team's goals were to 1) develop an integrated modeling framework that will be used to assess the effects of sea-level rise on the viability of Florida snowy plover, piping plover, and red knot populations, and 2) link bird management alternatives at both the local installation scale and the regional (Florida Gulf Coast) scale. It will investigate the threat of a potential sea-level rise on the long-term persistence of shoreline-dependent birds and shorelines for military training.

The team is developing a series of integrated models that include a land-cover change model (Sea Level Affecting Marshes Model, or SLAMM) driven by sea level rise, a habitat model, and a metapopulation model (for snowy plovers) with a decision model for selection and evaluating environmental management alternatives. The decision-making model will evaluate the ecological, political, and economical criteria of the involved stakeholders to allow the selection of the best management alternative. Coupled with targeted monitoring of the species, it will form the basis of adaptive management policies. The SLAMM model simulates the dominant processes involved with coastal wetland conversions and shoreline modifications during long-term sea level rise. Among these processes are inundation, erosion, over wash, saturation, and accretion. The habitat model builds on SLAMM projections to predict the most favorable habitats for birds. The metapopulation model projects snowy plover population viability based on projections of future habitat availability and information about population dynamics and life history.

The project team is in the process of assessing the vulnerability of Gulf

Coast shoreline habitat and future habitat availability for the snowy plover, piping plover, and red knot under several climate change scenarios and environmental management alternatives. Preliminary results indicate a likelihood of habitat loss and fragmentation (mainly salt-marshes, estuaries, and ocean beaches) for these species. Results also suggest that sea-level rise will cause a decline in suitable habitat and carrying capacity for the snowy plover, with a significant population decline and a substantially increased risk of local extirpation. Variations in the complexity of coastline landforms and the processes that shape them are strongly associated with the shrinking and splitting of suitable habitat patches. The future connectivity among snowy plover subpopulations along the Florida Gulf Coast should remain stable. However, the risk of local extirpations may strongly increase as population numbers drop and foraging and breeding sites shrink.

This integrated modeling approach will provide military decision-makers with a wide range of likely outcomes for shoreline-dependent birds under various land management approaches. The alternatives may include concentrating military training and testing in areas projected to be less sensitive to birds and scheduling training activities in seasons when the birds are less vulnerable. Although the impacts of beach nourishment (pumping sand from the ocean floor onto beaches) on shoreline-dependent birds are not fully understood, it may be a necessary engineering solution for maintaining coastal military training lands. Nourishment designs that preserve the vertical beach profile (the beach slope), dunes, and overwash areas important to nesting and brood foraging habitats may be necessary for the long-term conservation of shorebirds. The modeling approach being applied in coastal Florida may

be useful in predicting risks for other species and other coastal locations in the U.S.

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*I. Linkov and R. Fischer are with the U.S. Army Engineer Research and Development Center. M. Convertino, M. Chu-Agor, G. Kiker, C.J. Martinez, and R. Muñoz-Carpena are with the University of Florida. H.R. Akçakaya and M. Aiello-Lammens are with the State University of NY.*

# Radaring in on Migrating Birds

by Richard A. Fischer, Jonathon J. Valente, Michael P. Guilfoyle, and Sidney A. Gauthreaux

Department of Defense (DoD) lands include large, undeveloped landscapes with important habitat for birds during all phases of their life cycle. Military lands and waters can be particularly valuable for migrating birds requiring stopover habitat to rest and refuel en-route between distant seasonal ranges. This provides an opportunity for DoD installations, many of which occur along major migration routes, to play a critical role in protecting migrant birds. Recent developments in radar technology have provided powerful tools for investigating migrant departure from stopover habitat, as well as movements through military airspace, information that is crucial for assisting with flight safety of aircrews.

The DoD Strategic Environmental Research and Development Program (SERDP) provided funding to the U.S. Army Engineer Research and Development Center, Clemson University Radar Ornithology Laboratory, and the University of Southern Mississippi to investigate migratory bird use of military installations. The team used WSR-88D (NEXRAD) radar to investigate spring and fall migrations at 40 military installations across the United States, and to identify stopover hotspots based on radar images of birds departing from installation habitats (“exodus events”). It closely examined patterns on or near three military installations (Eglin Air Force Base, Florida; Fort Polk, Louisiana; and Yuma Proving Ground, Arizona) and developed

migration forecast models for those locations for use in reducing the probability of collisions between birds and military aircraft. The team also compared nightly radar estimates of migrant exodus from and input to the study areas and observed daily changes in migrant abundances. The team used traditional ground-based transect surveys to compare the results from the two methods and to evaluate the effectiveness of estimating migrant stopover abundances with NEXRAD technology. Lastly, the team compared migrant use of diverse riparian habitats along the Colorado River near the Yuma Proving Ground.

Results indicated that approximately half of the installations examined via radar contained migrant stopover “hotspots,” reaffirming the importance of military installations to migrating birds. For the three installations examined in detail, the team successfully developed robust forecast models that natural resources managers can easily implement. Interestingly, the team found that daily changes in migrant abundances and species composition, as estimated by ground-based surveys, showed very poor correlation with the number of migrants estimated to be leaving and arriving at the study area nightly. Further research is necessary to understand when each technique should be used. Lastly, the team found that migrant abundance, species richness, and community composition in Arizona were all influenced by riparian vegetation composition, and



Lucy's warbler (*Vermivora luciae*), a species of concern. Photo by Dominic Sherony.

those habitats containing significant amounts of saltcedar (*Tamarix* spp.) had the lowest metric values. This research collectively suggests that NEXRAD can be used to broadly identify migratory hotspots on military installations, as well as improve flight safety on those installations with an aviation-based military mission. Smaller mobile radar technology and intensive ground-based surveys are needed to further distinguish fine-scale differences in habitat use by migrants within an installation's boundaries.

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*Richard A. Fischer, a research wildlife biologist with the U.S. Army Engineer Research and Development Center, can be reached at Richard.A.Fischer@usace.army.mil. Jonathon J. Valente, a data analyst with the U.S. Army Engineer Research and Development Center, can be reached at Jonathon.J.Valente@gmail.com. Michael P. Guilfoyle is a research wildlife biologist with the U.S. Army Engineer Research and Development Center. Sidney A. Gauthreaux, a Professor Emeritus with the Clemson University Radar Ornithology Laboratory, can be reached at sagth@clemson.edu.*

# Automated Biodiversity Monitoring

by T. Mitchell Aide and  
Carlos Corrada-Bravo

About three years ago, a team of students and professors studying biology, computer science, and electronic engineering established the Automated Remote Biodiversity Monitoring Network (ARBIMON) at the University of Puerto Rico. The purpose of the

network is to help researchers gather data in the field by creating software and hardware for continuous, long-term, remote monitoring of biodiversity. The team initially focused on acoustically monitoring birds, amphibians, and insects. However, it hopes to begin aquatic monitoring

in the near future using hydrophones to detect marine mammals and fish, and cameras to study threats to reef communities (e.g., coral bleaching).

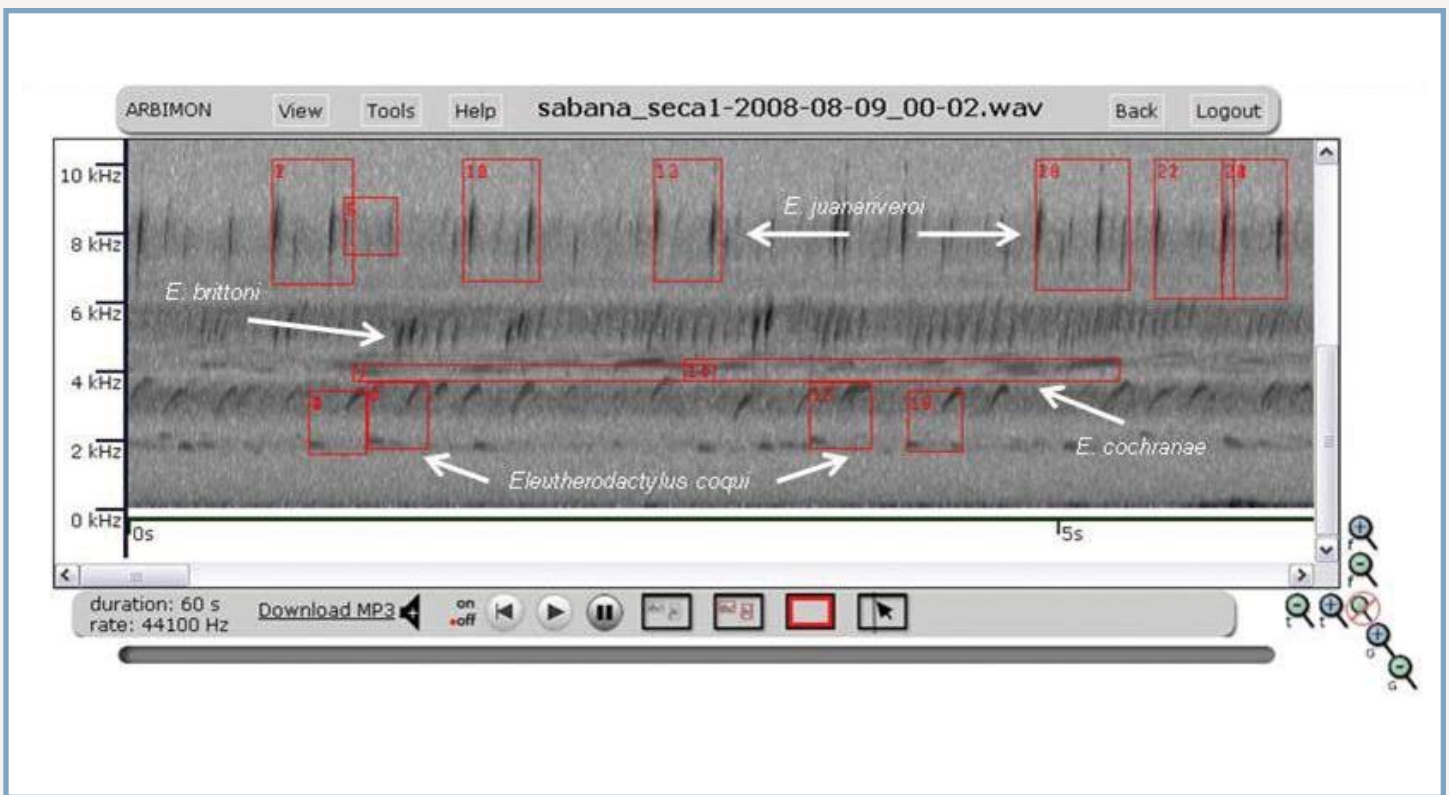
During the first stage of the project, the team designed two monitoring hardware systems: portable and permanent stations. The portable stations are less expensive and are easily moved to sample different habitats. They are powered by a 12-volt 12-amp battery that lasts about 10 days, and they record using a microphone, a preamp, an Apple iPod Touch, and a voltage regulator. The system records one minute of audio every 10 minutes, allowing 144 one-minute recordings per day.

Permanent stations are powered by a solar panel and car battery, and the data are transmitted to a base station by a Yagi antenna. The base station includes a receiving antenna connected to the local network and a laptop computer with an external hard drive for local backup. Once the files are stored locally, they are forwarded to the project server in Puerto Rico, where they are stored, processed, and displayed on the project website, virtually in real-time. Permanent recording stations are located in Puerto Rico, the Pohakuloa Training Area on the Big Island in Hawai'i, and Ft. Huachuca, Arizona, where other remote research projects take place.

Recently, the ARBIMON team made a major breakthrough in automating species identification using Hidden Markov Models (<http://en.wikipedia>.







org/wiki/Hidden\_Markov\_model). They accomplished this by developing a formula that automatically marks all acoustic events (such as the sounds made by various species) above background noise to determine regions of interest for the next phase of research. Following this step, experts are brought in to listen to multiple examples of a species' call and associate the acoustic events (i.e., notes) that compose each individual call. This information is then used to create a filter that feeds data to the Hidden Markov Models and create a match between certain species and their vocalizations. For example, the first species identification model focused on the common coqui frog (*Eleutherodactylus coqui*). Twenty random calls were used to train the system, and then more than 20,000 one-minute recordings were processed in 30 minutes. Inspection of 100 random recordings showed that the model correctly identified the presence or absence of this species with a high level of accuracy (over 90 percent). In light of these encouraging findings,



the team is working on a web interface that will allow any user to develop and test species identification models for additional species.

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*T. Mitchell Aide, a Professor in the Department of Biology, University of Puerto Rico – Rio Piedras, can be contacted at tmaide@yahoo.com. Carlos Corrada-Bravo, Associate Professor, Department of Computer Science, University of Puerto Rico – Rio Piedras, can be reached at cjcorrada@uprrp.edu.*

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**(Opposite page): A permanent biodiversity monitoring station located on the Pohakuloa Training Area in Hawaii.** Photo courtesy of DoD.

**(This page top): In this recording from Sabana Seca, Puerto Rico, algorithms have automated the identification of three species frogs. We are working on algorithms for the fourth species and for the bird species in the area.** Photo courtesy of DoD.

**(This page bottom): A red-eye coqui (*Eleutherodactylus antillensis*) endemic to Puerto Rico.** Photo by Leopoldo Miranda-Castro.

# Developing a Strategic Plan for Herpetofauna on Military Lands

by Robert E. Lovich, Chris Petersen, Priya Nanjappa, Ernesto Garcia, and Michael Lannoo

Department of Defense (DoD) installations exist to provide a foundation for military readiness in order to defend and protect the United States and its allies. In support of the military mission, many of these installations maintain expanses of largely undeveloped open space that often contain ecologically significant natural resources. These resources provide habitat for a broad spectrum of native flora and fauna, including herpetofauna (amphibians and reptiles), many of which are rare or federally listed as threatened or endangered species.

DoD also recognizes that conserving the essential components of ecosystems is necessary to ensure a sustainable

training platform and minimize the potential for regulatory/statutory restrictions, such as those that could result from the Endangered Species Act. In 2009, the DoD Legacy Resource Management Program initiated the development of a Strategic Plan for the recently established DoD Partners in Amphibian and Reptile Conservation (PARC) Program. The purpose of the plan is to develop an amphibian and reptile conservation strategy that can be implemented through partnerships. The focus is on reducing and mitigating the threats to amphibians and reptiles on DoD lands, while protecting and sustaining the military mission. The objective is to better integrate amphibian and reptile



conservation and management on the DoD landscape.

With the comprehensive resources that PARC and DoD bring to bear, we anticipate that DoD will be better able to address amphibian and reptile conservation issues while simultaneously supporting military readiness. This strategic plan will promote enhanced conservation and natural resources management on military installations in the U.S.





and provide a framework for similar activities on DoD installations throughout the world.

The draft version of the plan was completed by March 2011, in time for the National Military Fish and Wildlife Association annual meeting and will be made available for comment by the DoD natural resources community at large. It is essential to involve DoD natural resources personnel in the development of the plan, as its implementation will give all of DoD the chance to programmatically manage and conserve herpetofauna for the first time.

The final DoD PARC Strategic Plan will be distributed widely to DoD installations and personnel, with

copies available both online and in print. Doing so will allow DoD natural resources staff and land managers to integrate the broad herpetological expertise of the PARC network with specific management activities on DoD installations. This combination of guidance and expertise will help ensure that military readiness is not impacted as a result of degrading ecosystem health (amphibian and reptile population die-offs, declines, or extirpations).

In this time of disappearing natural resources, habitats, and species, the defenders of our great nation have the opportunity to count themselves among the nation's leaders in herpetofaunal and landscape conservation. DoD PARC is proud to support the nation's

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*Robert E. Lovich, a natural resources specialist with the Naval Facilities Engineering Command (NAVFAC) in San Diego, CA, can be reached at [robert.lovich@navy.mil](mailto:robert.lovich@navy.mil). Chris Petersen, a natural resources specialist with NAVFAC in Norfolk, VA, can be reached at [chris.petersen@navy.mil](mailto:chris.petersen@navy.mil). Priya Nanjappa, Amphibian & Reptile Coordinator and State Liaison to PARC for the Association of Fish and Wildlife Agencies, Washington, DC, can be reached at [pnanjappa@fishwildlife.org](mailto:pnanjappa@fishwildlife.org). Ernesto Garcia, Executive Director of Friends of PARC, can be reached at [egarcia@friendsofparc.org](mailto:egarcia@friendsofparc.org). Michael Lannoo, a professor in the Department of Anatomy and Cell Biology Indiana University School of Medicine, Terre Haute, can be reached at [mlannoo@iupui.edu](mailto:mlannoo@iupui.edu).*

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*Photos by DoD.*



# Do Frogs Still Get Their Kicks on Route 66?

## A Transcontinental Survey for a Killer Fungus

by Christopher Petersen,  
Robert E. Lovich,  
Michael J. Lannoo,  
Priya Nanjappa and  
Ernesto R. Garcia



One of the species surveyed during the cross-country study was the green frog (*Rana clamitans*). Photo by Dr. Joe Mitchell.

After surviving the last 300 million years, amphibian populations are in precipitous decline worldwide. One-fifth of the world's amphibians may now face extinction. The decline is the result of numerous problems, including habitat loss and fragmentation, competition and predation from non-native species, increased ultraviolet radiation, climate change, and diseases and pathogens.

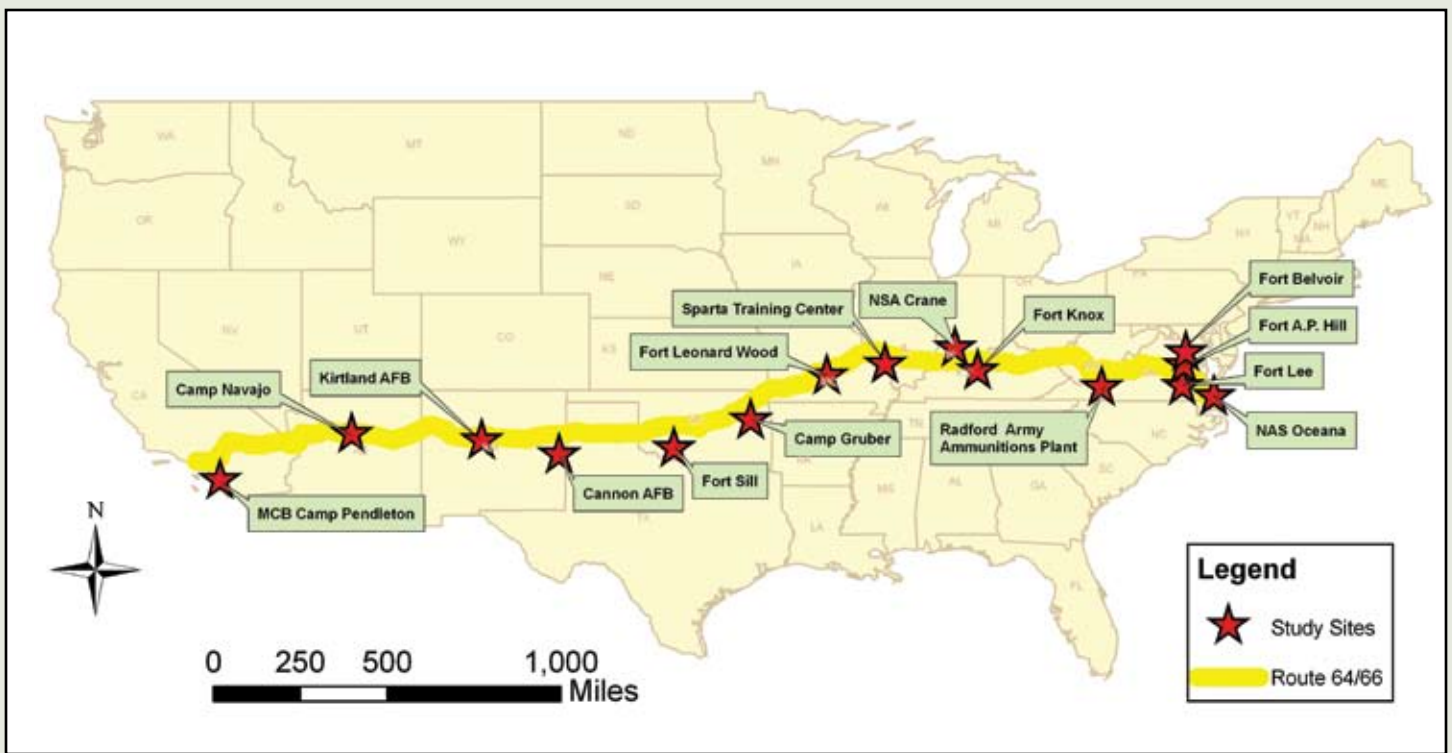
The amphibian disease chytridiomycosis (caused by the fungus *Batrachochytrium dendrobatidis* or Bd) has been a major factor in many population declines and extinctions. Bd is now widespread throughout many geographic regions and is known to occur in native amphibian populations on every continent (except Antarctica, where there are no amphibians).

To address this growing problem, the Partners in Amphibian and Reptile

Conservation (PARC), U.S Fish and Wildlife Service (FWS) Division of the National Fish Hatchery System, and other partners and sponsors held an international conference, "Amphibian Declines & Chytridiomycosis: Translating Science into Urgent Action" in 2007. The aim of the conference was to share information on research and management related to amphibian declines, with an emphasis on chytridiomycosis. One result has been a worldwide mapping effort (see <http://www.spatial-epidemiology.net/bd/>). As mapping progressed, it became apparent that little sampling had occurred on Department of Defense (DoD) installations. DoD lands provide an impressive array of amphibian and reptile diversity and habitats. Sampling DoD sites for Bd was identified as an important part of the North American mapping effort and equally important for evaluating the general health of amphibians on DoD lands.

So, you might ask, what does this have to do with Route 66? In 2009, we (the authors) received funding from the DoD Legacy Resource Management Program to conduct a transcontinental transect designed to assess the presence of Bd on DoD lands. We sampled 15 installations along U.S. Highway 66 from California to central Illinois. The transect then continued from the Midwest to the Atlantic Seaboard along Route 64. With the completion of this project, we anticipated answers to, or at least insight into, these questions:

- At which DoD sites would Bd be detected?
- What are the infection rates at the surveyed sites?
- Is there a temporal pattern to the presence of Bd?



(Below): Swabbing a pine woods treefrog (*Hyla femoralis*) to detect fungal disease . Photo by Dr. Joe Mitchell.

- Is there a spatial pattern to the presence of Bd?
- What species tested positive for Bd?
- Are some species more susceptible to Bd fungus than others?

A team of more than 15 people comprised of PARC members, DoD biologists/environmental managers, and volunteers conducted the field work. They sampled three wetland habitats on each of the 15 installations in spring/early summer, mid-summer, and late summer/fall in 2009. The study represents the most geographically extensive single survey/transect for Bd infection ever conducted.

The team followed a non-invasive protocol for capturing and swabbing amphibians. This ensured consistency in data collection and prevented the potential transfer of Bd, if present, from one amphibian to another and from one installation to another. The team then sent field collected swabs to a laboratory to test for the presence of the genetic Bd “fingerprint.”



The results indicated Bd presence at 13 of the 15 installations sampled. It was not detected at the other two sites, Camp Navajo in Arizona and Fort Sill in Oklahoma. A total of 1,306 amphibians were sampled, and 217 (16.6 percent) of the swabs tested positive for Bd. Half of the species surveyed (15 of 30) tested positive for Bd. Species infected with Bd covered a wide phylogenetic range including four species of plethodontid (lungless) salamanders, three species of toads, five hylid frogs (or “tree frogs”), and four ranid frogs (or “true frogs”). At no point during this study did the team observe any dead or dying amphibians.

There was a strong spatial component to the dataset. The 10 tested DoD installations in the nation’s eastern temperate zone (Camp Gruber, Fort Leonard Wood, Sparta Training Center,

Naval Support Activity Crane, Fort Knox, Radford Army Ammunitions Plant, Fort A.P. Hill, Fort Belvoir, Fort Lee, and Naval Air Station Oceana) had higher rates of Bd infection (18.9 percent) than the five bases (Marine Corps Base Camp Pendleton, Camp Navajo, Kirtland Air Force Base, Cannon Air Force Base, and Fort Sill) situated in the arid west (4.8 percent). There also was a strong temporal (seasonal) component, with 78.5 percent of positive samples found in the first (spring/early-summer) sampling period. Taken together, the data suggest that the spatial pattern of Bd presence is due to variations in moisture levels (with moisture promoting infection rates), whereas temporal patterns may be due to moisture availability (with Bd present at the highest rates during the wettest times of the year). The final report

and a peer-reviewed manuscript with complete details are forthcoming.

The study findings will support DoD natural resources managers and environmental specialists by providing baseline data on the health of amphibian populations. They will also be incorporated into the emerging disease mapping project, helping researchers look at national patterns and trends of surveyed sites, die-offs, and spread of this disease. We hope the data may ultimately aid in preventing population declines and avoiding further restrictions on current military base operations.

The DoD Legacy Resource Management Program has funded additional sampling, scheduled for 2011, at other DoD installations across the U.S.

**Green treefrogs (*Hyla cinerea*) resting on a cattail.** Photo by Paul Block.





**A Cope's gray treefrog (*Hyla chrysoscelis*) emits its call.** Photo by Dr. Joe Mitchell.

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### **Acknowledgements**

The authors would like to recognize Dr. Joseph Mitchell and Dr. Christopher Phillips for their extensive field work and dedication on this project. We also would like to recognize Irene Macallister (USACOE) for her laboratory analysis of the field collected data. Lastly, this study could not have been conducted without the assistance of the natural resource and environmental managers at the DoD installations or without the funding from the DoD Legacy Resource Management Program.



# DoD Joins the Battle to Save Bats

by Christopher Dobony,  
Eric Britzke, Mark Ford, and  
Raymond Rainbolt

**W**hite-nose syndrome (WNS) is a wildlife health concern of unprecedented scale that has decimated bat populations in eastern North America. WNS, or its presumptive cause, the cold-hardy fungus *Geomyces destructans*, has spread in recent years throughout the eastern United States and Canada, and as far south and west as Oklahoma. Department of Defense (DoD) natural resource managers and biologists are working with their counterparts in other agencies on research to combat the threat of widespread bat extinctions.

The distinctive white fungus often appears on the muzzles, wings, ears, and tails of bats during and just after hibernation. It grows at temperatures from approximately 0 to 20° C (approximately 32 to 68° F), which corresponds to the body temperature of hibernating bats. Unfortunately,

during normal hibernation, the immune system of bats becomes relatively inactive, leaving them vulnerable to this fungal infection. Bats with white muzzles, dead bats on cave floors, or emergence of bats from hibernacula during mid-winter months (too early in the year to have a reliable food supply) are signs of WNS. It is unknown whether affected bats emerge early in an attempt to forage to restore depleted fat reserves, or to escape the increased individual agitation and group disturbance as WNS-infected bats become active. Regardless, bats then die from cold weather exposure.

Although variable among bat species, mortality rates at hibernacula of 70 to 95 percent have been reported within 2 years of an initial infection. Bat-to-bat transmission is known to occur, and the effects of humans and other environmental factors in the transmission cycle, though unknown,

are also believed to contribute to the problem.

WNS has most severely affected the Northeast's most common "cave" bat species: the big brown bat (*Eptesicus fuscus*), eastern small-footed bat (*Myotis leibii*), little brown bat (*Myotis lucifugus*), northern bat (*Myotis septentrionalis*), tricolored bat (*Perimyotis subflavus*), and the endangered Indiana bat (*Myotis sodalis*). The endangered gray bat (*Myotis grisescens*), the cave bat (*Myotis velifer*), and southeastern bat (*Myotis austroriparius*) have recently tested positive for the fungus. The timing of WNS has postponed considerations for delisting the gray bat, tempered the optimism of increasing Indiana bat populations, and led to a petition to list the eastern small-footed and northern myotis species under the Endangered Species Act. Concern for the viability of the





endangered Virginia big-eared bat (*Corynorhinus townsendii*) prompted the U.S. Fish and Wildlife Service, Smithsonian Institution, and West Virginia Division of Natural Resources to develop a captive holding program as an “ark” in an attempt to prevent outright extinction.

Although our understanding of WNS is still limited, researchers at numerous federal and state agencies, universities, and non-governmental organizations are diligently working to answer basic questions about WNS, devise management guidelines, and prepare managers in unaffected areas for its arrival. DoD natural resource specialists have historically collaborated with federal and state biologists to manage endangered species like the Indiana and gray bats, and with the onset of WNS at military installations, DoD has also become involved with research on this disease.

Army biologists at Fort Drum, New York, have been working with federal and state agencies to collect information at a summer maternity colony of little brown bat known to be infected with WNS. Additionally,

although WNS mortality is most prevalent and obvious at hibernacula, research at this Army installation has also documented how disease impacts are manifested during non-hibernation months. Numbers of bats captured per net-survey site at Fort Drum dropped by more than half since the onset of WNS on the installation, with the greatest declines occurring among the northern and little brown bat.

Unfortunately, with precipitous drops in the numbers of these formerly common bats and declines in already endangered species due to WNS, the complexities of accomplishing the military training mission and managing other uses of DoD lands will multiply.

In collaboration with Bat Conservation International, DoD hosted workshops in Nashville, Tennessee, and at nearby Fort Campbell, Kentucky, in November 2010 to help prepare military installations for the arrival of WNS. This workshop, funded by the DoD Legacy Resource Management Program, focused on challenges and opportunities unique to military installations, and provided a framework for DoD to assess risk on

the installations and to manage for bats and WNS. A similar workshop is also being developed for late summer or fall 2011.

It is difficult to predict the role WNS will play in natural resource management in the context of sustaining military mission requirements. However, it is vital for military installations to begin communicating with state and federal regulators about potential approaches for dealing with this important issue. If strategies can be developed early, potential military mission impacts may be identified, avoided, and/or mitigated prior to the arrival of WNS. DoD is known for its ability to adapt and overcome, and we hope that dealing with this disease threat will be no different.

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*Christopher Dobony, a fish and wildlife biologist with Fort Drum Military Installation, can be reached at Chris.Dobony@us.army.mil. Eric Britzke, a research wildlife biologist with the US Army Engineer Research and Development Center Environmental Lab, Vicksburg, MS, can be reached at Eric.R.Britzke@usace.army.mil. W. Mark Ford, Unit Leader of the USGS Virginia Cooperative Fish and Wildlife Research Unit, Virginia Tech University in Blacksburg, VA, can be reached at wmford@vt.edu. Raymond Rainbolt, Fish and Wildlife Program Manager at the Fort Drum Military Installation, can be reached at Raymond.E.Rainbolt@us.army.mil.*

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**(Opposite page): A bat showing signs of WNS.**

*Photo by Marvin Moriarty, USFWS.*

**(This page): Department of Defense, U.S. Fish and Wildlife Service, and NY State Department of Environmental Conservation personnel work to understand the impacts of WNS on bat survival and reproduction at Fort Drum Military Installation in northern NY.** *Photo by DoD.*

# A Call in the Night

## Monitoring Bats Acoustically

by Dr. Joseph M. Szewczak

**T**he U.S. Fish and Wildlife Service lists six North American bat species as endangered and many of them frequent U.S. Department of Defense (DoD) military installations. Bats perform a number of vital ecological services, such as acting as the primary consumers of nocturnal insects. Unfortunately, monitoring and assessing the health of bat populations has traditionally proven difficult since bats operate in the dark,

out of reach, and are mostly silent to human ears. Their small size and often cryptic appearance frequently make capture necessary in order to ensure correct species identification. However, capture is invasive, stressful for the animals, and resource intensive. Further, it subverts long-term monitoring, as bats will learn to avoid recapture and may not even return to the capture site.

Fortunately, bats, like birds, do “leak” considerable information about themselves into the environment through their vocalizations, and we can use these signals for non-contact monitoring. However, unlike birds, bat vocalizations do not so readily facilitate identification. Bats navigate by a process called echolocation, sending calls into the night and listening for the sound reflected from their surroundings. Bats have optimized



their vocalizations for navigation and foraging rather than for identifying or attracting others of their species. Accordingly, they have undergone no selective pressure to differentiate the calls of one species from another. As a further complication, bats adjust their call structure to suit particular tasks. Identifying bat species from their calls thus presents the challenge of distinguishing subtle signal differences from a repertoire of call types with many overlapping characteristics among species.

With support from the DoD Strategic Environmental Research and Development Program (SERDP), I worked with colleagues and my graduate students at Humboldt State University to develop technology that automatically records and classifies bats by species from their echolocation calls. This initiative builds upon a bat call analysis program I developed named SonoBat. Learning to identify bat species by voice would seem straightforward: go out and record them and see who says what. However, although ultrasound microphones can record bats with relative ease, knowing which species and which individual made the sound in the dark sky presented a challenge. Furthermore, a held captive bat does not provide vocalizations that are representative of those they make in free flight, so researchers cannot just capture and record sounds.

My crew and I used a variety of methods to pair recordings with known species, and we constructed an extensive reference library from each species to complete their call repertoires. These methods included flying bats on tethered ziplines and tracking light-tagged bats. Working somewhat like an inverted dog run, an elastic tether slides along a fixed zipline to constrain the bat's flight path to facilitate recording in the field.

Recordings made from the ziplined bats provided calls like those that bats typically make when they fly near the ground or among obstacles. To record the kinds of calls that bats make in open air flight, we temporarily attached small cyalume light sticks that enabled visual tracking of known bats.

Recording bat echolocation calls with high-resolution, full-spectrum data enables an intelligent call trending routine we developed that can automatically track the trend of a call through noise, echoes, and other distorting effects and automatically extract signal characteristics. The automated data extraction routines embody the heart of the system. Applying them to the approximately 10,000 recorded sequences of known bats we recorded across the United States generated a database of several million call parameters.

From these data, the team developed automated classifiers for bat species in Northeastern, Midwestern, Pacific Northwest, Great Basin, and Montane North regions of the United States. Systems to classify bat species from their calls in other regions will follow. Because the call characteristics of many species overlap in parts of their repertoires, the classifiers cannot discriminate all recordings to species. The classifier performance varies by region, but they typically achieve a 95-98 percent correct identification rate. Our team also collaborated with hardware developers to provide automated recording units that enable long-term unattended recording.

These hardware and software solutions enable the monitoring of bat populations on unprecedented spatial and temporal scales compared to traditional capture and survey methods. They will contribute vital data to track ongoing and emerging bat conservation issues, such as



recognizing potential effects of wind energy development on bats and the impacts of white nose syndrome on bat populations.

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*Joseph M. Szewczak, Associate Professor, Humboldt State University, can be reached at [joe@humboldt.edu](mailto:joe@humboldt.edu).*

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**(Opposite page):** A canyon bat (*Parastrellus hesperus*) flying along a zipline attached by an elastic tether. The elastic tether gently keeps the bat on track and enables the bat to achieve a steady flight along a known path to facilitate recording the bat's echolocation calls.

**(This page):** Eastern red bat (*Lasiurus borealis*) released with a cyalume light tag to enable visual tracking and recording the bat's calls as a known species. Adhesive from nontoxic paper glue sticks affix the tags and enable the bats to groom the tags off when they reach a roost.

*Photos courtesy of Joseph M. Szewczak.*

# Restoring the Pallid Sturgeon

by Jim Brannen and Josh Wilhelm

**T**he pallid sturgeon (*Scaphirhynchus albus*), a large-growing fish native to the Mississippi and Missouri rivers, was listed in 1990 as an endangered species due to widespread habitat alteration, over-fishing, hybridization with shovelnose sturgeon, and an apparent loss of natural reproduction.

To help overcome the latter problem, a propagation program using progeny from wild pallid sturgeon was

established. The goal of this program is to produce and stock pallid sturgeon until they can reproduce again and become a self-sustaining population. Shortly after the species was listed, the Pallid Sturgeon Recovery Plan recommended restoring habitat and natural river flow conditions needed for natural reproduction.

In the last 20 years, the Nebraska Game and Parks Commission (NGPC), along with other state and federal

agencies (including the Department of Defense), have made great strides towards recovering a self-sustaining pallid sturgeon population. The NGPC is preparing for its fourth annual broodstock collection effort since the spring of 2008. This is a large-scale effort dependent on volunteers and additional personnel to cover a broad range of the upper channelized Missouri River bordering Nebraska. Sampling is conducted using 200-foot (60-meter) trotlines with 40 hooks per





line, each baited with worms. Trotlines have proven to be the most effective tool available for targeting adult pallid sturgeon to be used for propagation.

Last year's sampling effort collected 167 pallid sturgeon in 12 days. Thirty-seven were transported to Blind Pony State Fish Hatchery (Missouri) for evaluation of their reproductive condition. A total of five family lots were produced from four females and five males. As a result of these spawning efforts, a total of 2,974 pallid sturgeon from two family lots were recently tagged and stocked into the Missouri River. The remaining fish will be held at Gavins Point National Fish

Hatchery (South Dakota) and Neosho National Fish Hatchery (Missouri) over the winter to allow for increased growth and potentially higher stocking survival rates.

For more information, visit: <http://barbsandbacklashes.files.wordpress.com/2010/04/2010-broodstock-publication.pdf>

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*Josh Wilhelm, a conservation technician with the Nebraska Game and Parks Commission, can be reached at [Josh.Wilhelm@nebraska.gov](mailto:Josh.Wilhelm@nebraska.gov) or 402-471-1517.*

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**Col. Ruch, Omaha District Commander, enjoys spending a day assisting the state of Nebraska with the collection of pallid sturgeon bloodstock last spring.** *Photo courtesy of Nebraska Game and Parks Commission.*

# Weapons Testing and Endangered Fish Coexist in Florida

by Howard Jelks, Bill Tate, and Frank Jordan

Okaloosa darters (*Etheostoma okaloosae*) are small fish found only in a few streams in the Florida panhandle. This species has been listed since 1973 as endangered due to habitat alteration resulting from erosion, the potential competition from brown darters (*E. edwini*), and a limited geographic distribution. In recent years, however, Okaloosa darters have benefited from improved resource management and adaptive population monitoring techniques developed collaboratively by the U.S. Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS), Loyola University New Orleans, and Eglin Air Force Base. As a result, the FWS reclassified the Okaloosa darter to the less critical category of threatened in March 2011.

Okaloosa darters are found in only six coastal stream systems, with a combined length of about 230 miles (400 kilometers), which flow through longleaf pine sandhills. The low nutrient, sandy soils of the region produce relatively clear groundwater-fed streams, interspersed with woody debris and patches of aquatic vegetation. Unfortunately, these sandy soils also are relatively unstable, and certain land use practices resulted in severe erosion and smothering of Okaloosa darter stream habitat.

Over 95 percent of the species' geographic range is on Eglin AFB, where the Air Force conducts its primary mission of full-service air armament development through weapons system research, development, testing, and evaluation.

While fulfilling its military mission, Eglin also manages its natural resources, acting as a steward to protect plants and animals for future generations. Weapons testing and Okaloosa darter recovery may sound incompatible, but Eglin has established partnerships to develop and implement effective natural resources management programs. Working with the FWS and Eglin AFB, USGS and Loyola University researchers provided leadership in helping to form the Okaloosa Darter Recovery Group and draft the 1998 Revised Recovery Plan. Members of the Okaloosa Darter Recovery Group monitor, manage, and direct recovery actions for the species, including the adoption of new techniques for monitoring status and trends.

Beginning in the mid-1990s, USGS and Loyola personnel have worked to develop and refine innovative methods for population monitoring that are more accurate and cause less habitat disturbance than traditional methods (e.g., electrofishing or seining). Researchers using masks, snorkels, and plastic nets have been visually monitoring Okaloosa darter populations on Eglin AFB. The improved estimates indicate that there are currently 300,000 to 800,000 Okaloosa darters, many more than originally thought. In addition to providing long-term abundance data, visual methods are used to evaluate habitat restoration projects and inform recovery decisions.

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**Growing only to 2 inches (50 millimeters) in length, Okaloosa darters typically live in waters around plants, roots, or woody debris along the margins of shallow, sandy streams which are 3-30 feet (1-10 meters) wide.**



The Okaloosa Darter Recovery Group initially focused on examining threats to Okaloosa darters and advising natural resources managers on recovery strategies. Many of the threats identified in the recovery plan have been eliminated or substantially reduced. Eglin AFB has made a considerable investment to correct erosion problems, restoring borrow pits and road crossings by contouring the landscape and planting vegetation. As stream habitat has improved, the recovery group's monitoring shows that numbers of Okaloosa darters have increased significantly.

Currently, Eglin is actively removing impediments to darter movements, such as impoundments and elevated culverts, which reduce the available stream habitat. Mill Creek, which traverses the fairways of Eglin's golf course, is the smallest Okaloosa darter stream. Where the creek had become a series of rusting culverts and muck-filled ponds, there is now a restored stream channel with emergent plants and embedded woody debris. The one culvert that remains is large enough to support four plexiglass portals, so plants and darters can now



**USGS researcher surveying Okaloosa darters.** Photo by USGS.

exist underneath the fairway with its roving golf carts and flying white balls. Golfers appreciate the new look, even if a few balls stray into the stream. The recovery group is monitoring Okaloosa darter colonization of the repaired stream and assessing the stability of the newly established aquatic community.

By developing innovative approaches to population monitoring, the Okaloosa Darter Recovery Group assisted the FWS in making informed recovery decisions, leading to the proposal to reclassify the Okaloosa darter as threatened. This demonstrates that endangered species recovery can take place on America's active military lands.

**Hellfire weapon test at Eglin Air Force Base.** Photo by DoD.



For more information, see [http://sesc.usgs.gov/freshwater\\_fauna/okaloosa\\_darter.html](http://sesc.usgs.gov/freshwater_fauna/okaloosa_darter.html).

*Howard Jelks, a fish biologist with the U.S. Geological Survey, can be reached at [hjelks@usgs.gov](mailto:hjelks@usgs.gov). Bill Tate, a fish biologist with the FWS at the Eglin AFB Natural Resources Office, can be reached at [Bill\\_Tate@fws.gov](mailto:Bill_Tate@fws.gov). Frank Jordan, a Professor with the Department of Biological Sciences at Loyola University in New Orleans, can be reached at [jordan@loyno.edu](mailto:jordan@loyno.edu).*

# Defending Mussel Populations on Military Lands

## Taking the Initiative on Managing Species at Risk

by Eric Wolf and Verl Emrick

**H**ealthy rivers and streams in the southeastern United States need freshwater mussels. Mussels feed by filtering bacteria, algae, and other small organic particles from the water, which benefits the environment by improving water quality. Freshwater mussels, however, have become the nation's most endangered group of animals. At present, 71 species of freshwater mussels in the U.S. are listed as endangered or threatened, and others are candidates for listing in the future.

Several rare mussels live in streams that flow through military lands. For example, the upper Nottoway River on Fort Pickett near Blackstone, Virginia, is home to one of the few remaining viable populations of the Atlantic pigtoe mussel (*Fusconaia masoni*) remaining in Virginia. Populations of the Atlantic pigtoe are in precipitous decline throughout the species' range, and the Department of Defense (DoD) classifies it as a "species at risk."

DoD is funding a cooperative research effort through its Legacy Resource Management Program to conserve declining populations of the Atlantic pigtoe before it is listed as endangered. Biologists with the Virginia Tech Conservation Management Institute and the U.S. Fish and Wildlife Service are propagating this species for reintroduction into the Nottoway River at Fort Pickett.

The propagation and culture of juvenile mussels for release into the wild is a component of many endangered species recovery plans. Freshwater mussel reproduction is a complex, multi-stage process that is dependent on certain seasonal and water conditions. Many mussel larvae, called glochidia, survive and grow by temporarily attaching themselves to the gills of a host fish and then dropping off into a suitable spot as they mature. The relationship between mussel and host fish can be species-specific (a particular mussel species relies on a specific fish species).

A key component of the Atlantic pigtoe reintroduction project is to identify the species of host fish this mussel needs for successful propagation.

By identifying the host fish species and refining techniques for feeding and holding adult and juvenile mussels, scientists can better raise captive-reared mussels and provide conditions to enhance their chances of survival in the wild. Future work will include research into the water conditions and habitat used by the Atlantic pigtoe







to find areas that are well suited for future releases.

Military lands are not only essential for training; they also provide unique opportunities for natural resource stewardship. The conservation and reintroduction of the Atlantic pigtoe at Fort Pickett will support more stable populations over a broad geographical range while reducing the need for listing under the Endangered Species Act and impacts on military readiness.

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*Eric Wolf, a wildlife biologist at the Virginia Tech Conservation Management Institute in Blacksburg, Virginia, can be reached at ewolf6@vt.edu. Verl Emrick, an ecologist at the Institute, can be contacted at vemrick@vt.edu.*

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**(Opposite page): This is a model of a living stream, used to hold mature mussels until release. Water is pumped in from one end and drained out the other to emulate stream flow.**

**(This page top): Mature Atlantic pigtoe mussel with identification tag attached just before release.**

**(This page bottom): Snorkelers systematically search the sand and gravel substrate of stream bottoms to find and identify freshwater mussels.** *Photos courtesy of Virginia Tech Conservation Management Institute.*



# Conserving Biodiversity on Military Lands

## A New Toolbox for Natural Resources Managers

by Douglas Ripley

In spring 2007, the U.S. Department of Defense (DoD) proposed updating and revising its popular 1996 DoD Biodiversity Handbook, which has been distributed widely in print and on line. In 2008, military natural resources managers and operations personnel throughout the country collaborated with NatureServe and The Nature Conservancy to develop a revised publication, *Conserving Biodiversity on Military Lands – A Guide for Natural Resources Managers*. Funded through the DoD Legacy Resource Management Program, a limited number of the revised biodiversity guides were published; however, an online version is available at [www.dodbiodiversity.org](http://www.dodbiodiversity.org).

An added feature of the 2008 biodiversity guide is the inclusion of a “Biodiversity Conservation Toolbox.” This appendix provides specific references, each with a hyperlink, to individual biodiversity research and management topics. The items are organized and linked to the following subjects in the guide:

- Chapter 1 – Biodiversity and the Military Mission
- Chapter 2 – Science
- Chapter 3 – Policy
- Chapter 4 – Encroachment

- Chapter 5 – Multiple Uses
- Chapter 6 – Endangered Species
- Chapter 7 – Invasive Species
- Chapter 8 – Disturbance Regimes
- Chapter 9 – Funding
- Chapter 10 – Partnerships
- Chapter 11 – Integrated Natural Resources Management Plans (INRMPs)

Items in each section include a wide array of background information on the specific topic of the chapter, including references for biodiversity conservation, research, training opportunities, DoD policy and guidance documents, and federal laws and Executive Orders. The toolbox is a “living” reference and thus will be updated and expanded regularly.

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*Dr. Douglas Ripley, U.S. Air Force Natural Resources Manager (Retired) and an environmental consultant, can be reached at [Ripley@powerc.net](mailto:Ripley@powerc.net).*

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**Extensive conservation monitoring, evaluation, and reintroduction programs at the Pennsylvania Army National Guard's Fort Indiantown Gap have been a major factor in the successful recovery of the regal fritillary butterfly.** *Photo by Joe Hovis.*



# U.S. FISH & WILDLIFE SERVICE CONTACTS

## WASHINGTON D.C. OFFICE Washington, D.C. 20240

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Rowan Gould, Acting Director

Gary Frazer, Assistant Director of Endangered Species

Jim Serfis, Chief, Office of Communication and Candidate Conservation

Martha Balis-Larsen, Chief, Office of Program Support

Nicole Alt, Chief, Division of Conservation and Classification

Rick Sayers, Chief, Division of Consultation, HCPs, Recovery, and State Grants

[www.fws.gov/endangered](http://www.fws.gov/endangered)

703-358-2171

## PACIFIC REGION—REGION ONE Eastside Federal Complex, 911 N.E. 11th Ave, Portland OR 97232

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Hawaii and other Pacific Islands, Idaho, Oregon, Washington

Robyn Thorson, Regional Director

[www.fws.gov/pacific](http://www.fws.gov/pacific)

503-231-6118

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Benjamin Tuggle, Regional Director

[www.fws.gov/southwest](http://www.fws.gov/southwest)

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Thomas O. Melius, Regional Director

[www.fws.gov/midwest](http://www.fws.gov/midwest)

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Cynthia Dohner, Regional Director

[www.fws.gov/southeast](http://www.fws.gov/southeast)

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[www.fws.gov/mountain-prairie](http://www.fws.gov/mountain-prairie)

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Geoff Haskett, Regional Director

[www.fws.gov/alaska](http://www.fws.gov/alaska)

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[www.fws.gov/cno](http://www.fws.gov/cno)

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