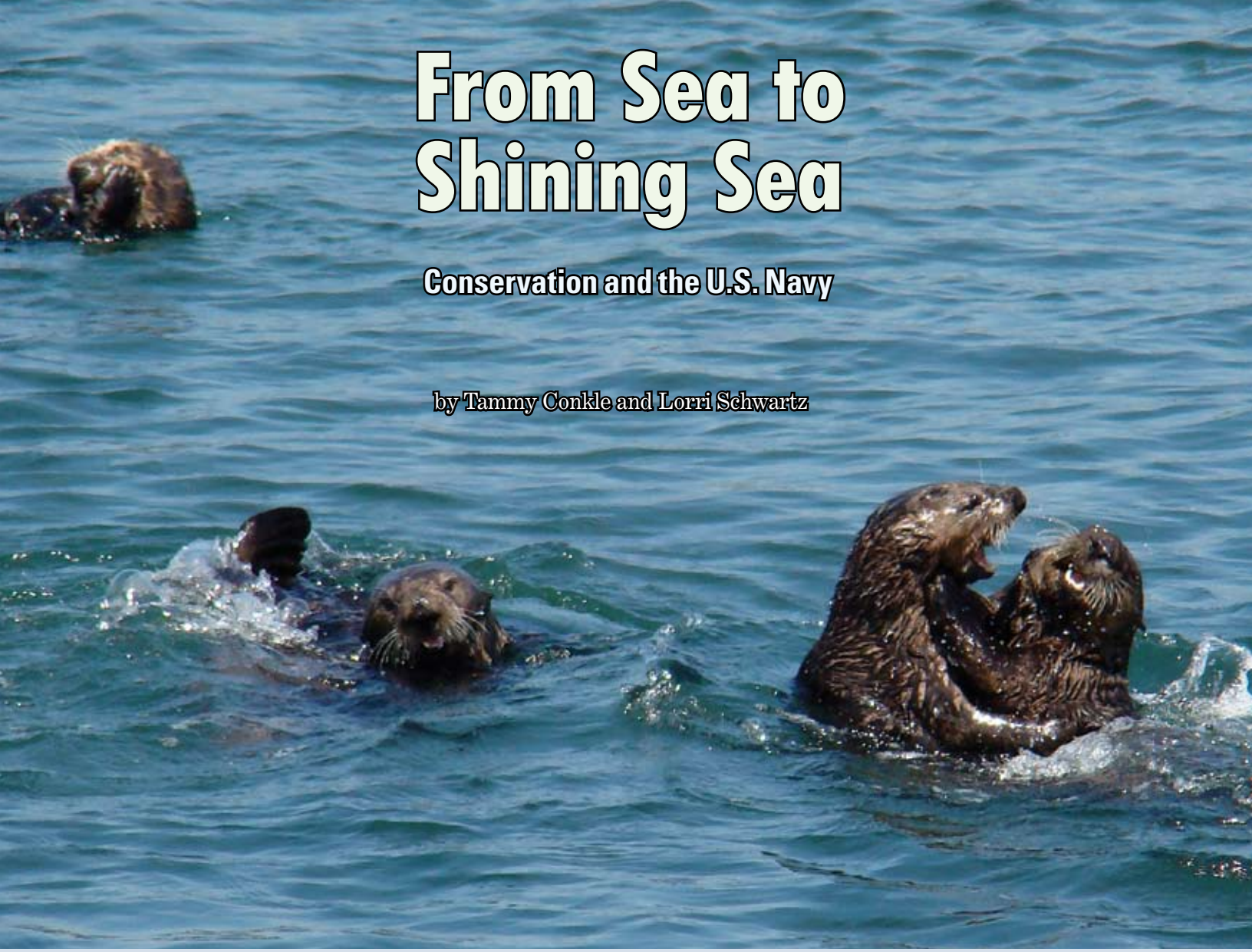

From Sea to Shining Sea

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

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

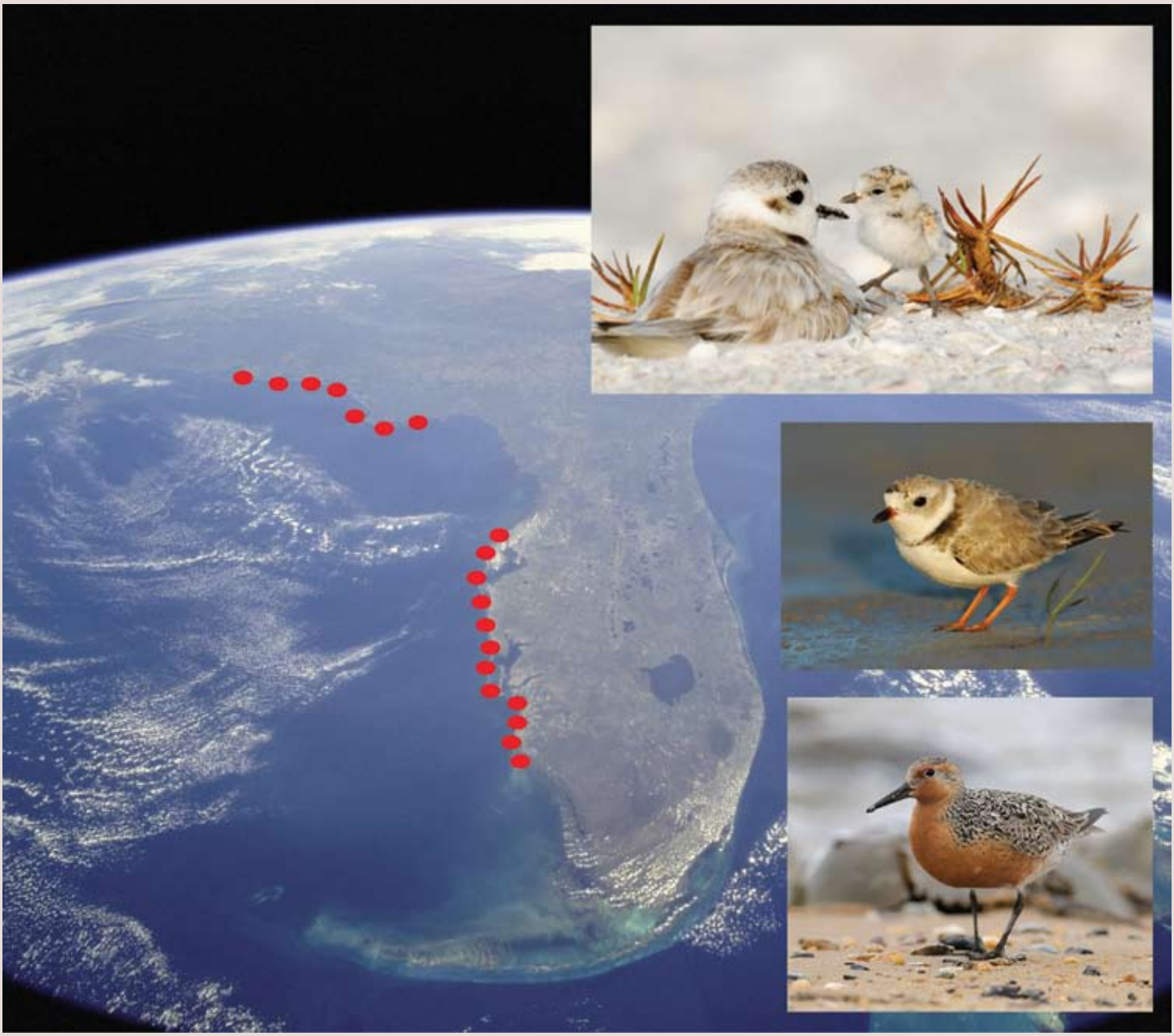
(This page bottom): Reticulated flatwoods salamander. *Photos by U.S. Navy.*

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,

(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.

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 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.

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

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Automated Biodiversity Monitoring

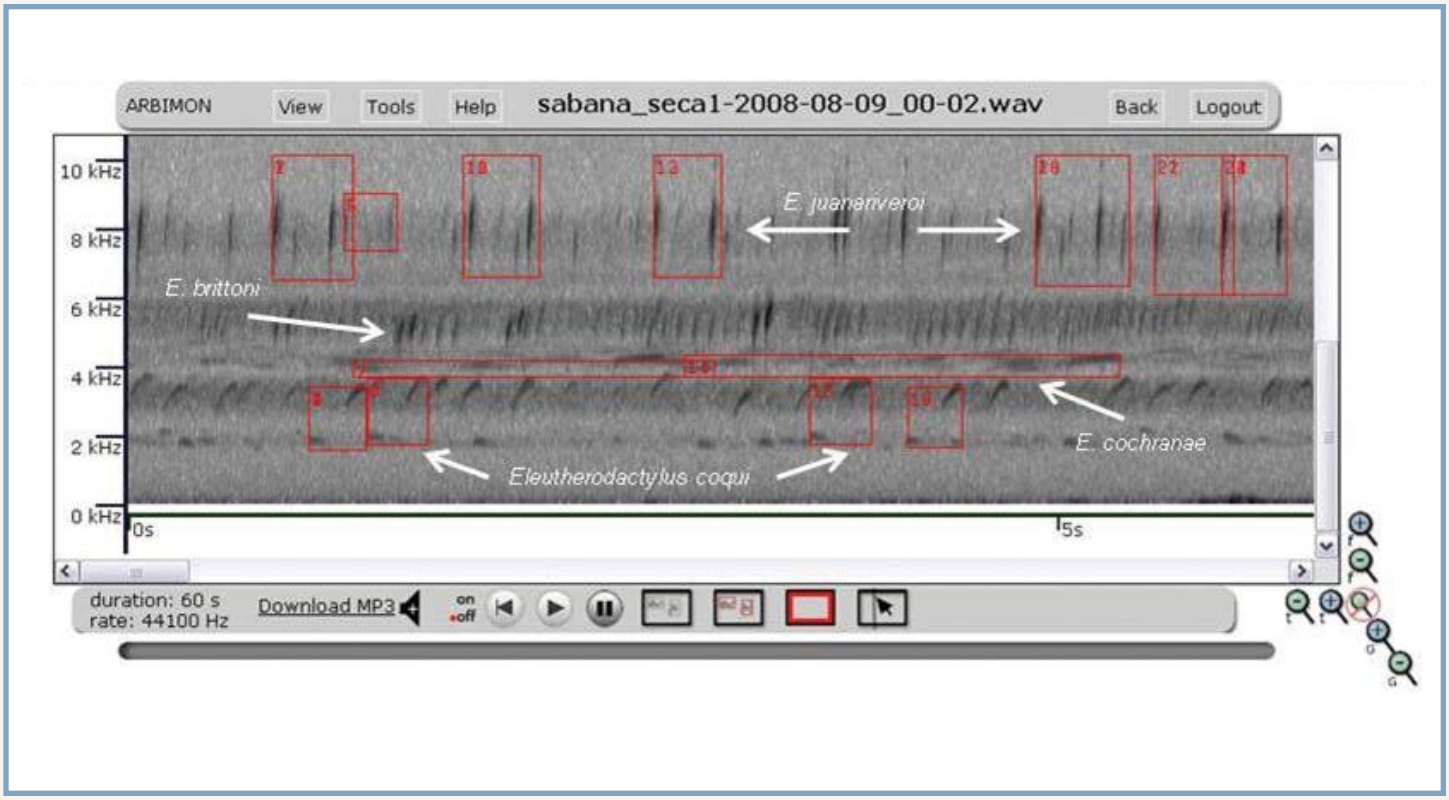
by T. Mitchell Aide and
Carlos Corrada-Bravo

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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(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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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-sountry study was the green frog (*Rana clamitans*). *Photo by Dr. Joe Mitchell.*

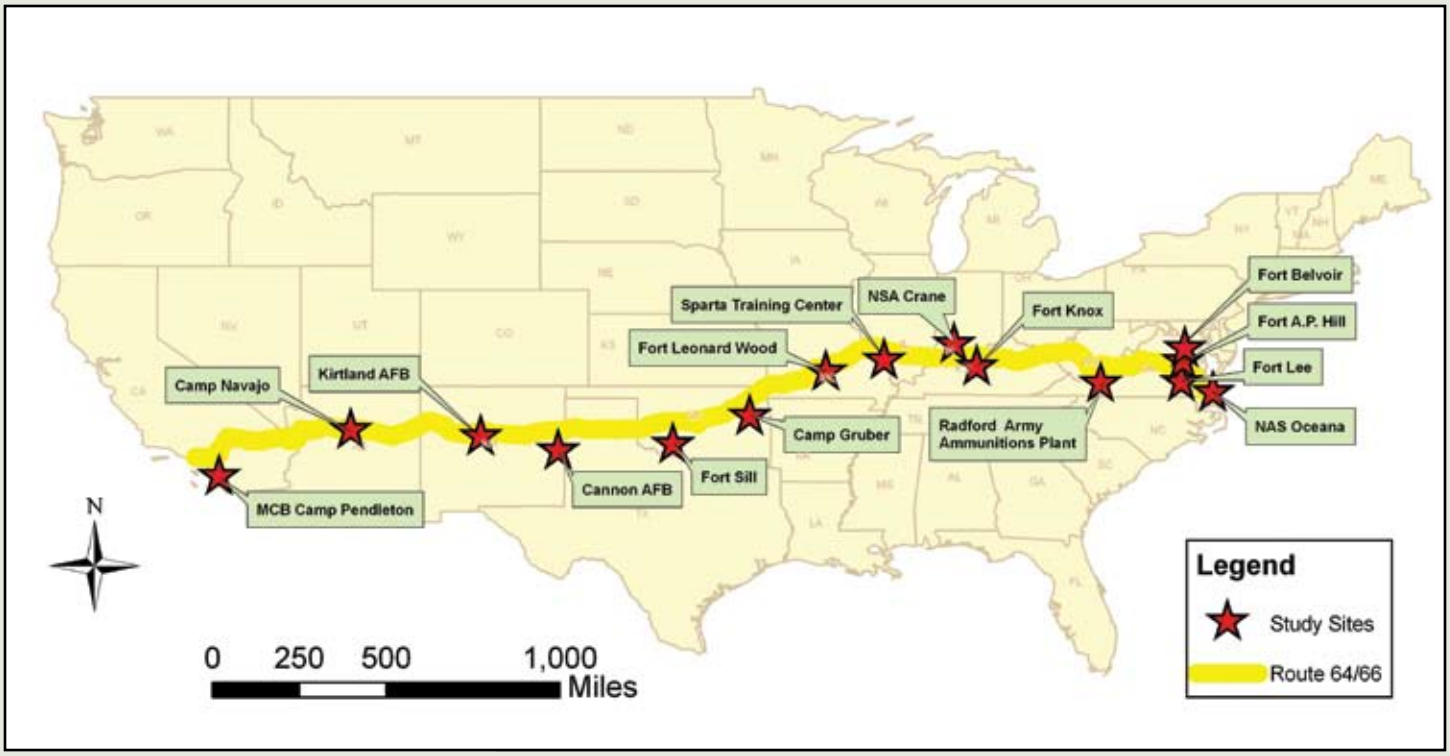
After surviving the last 300 million years, amphibian populations are in precipitous decline worldwide. One-fifth of the world's amphibians may now face extinction. The decline is the result of numerous problems, including habitat loss and fragmentation, competition and predation from non-native species,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

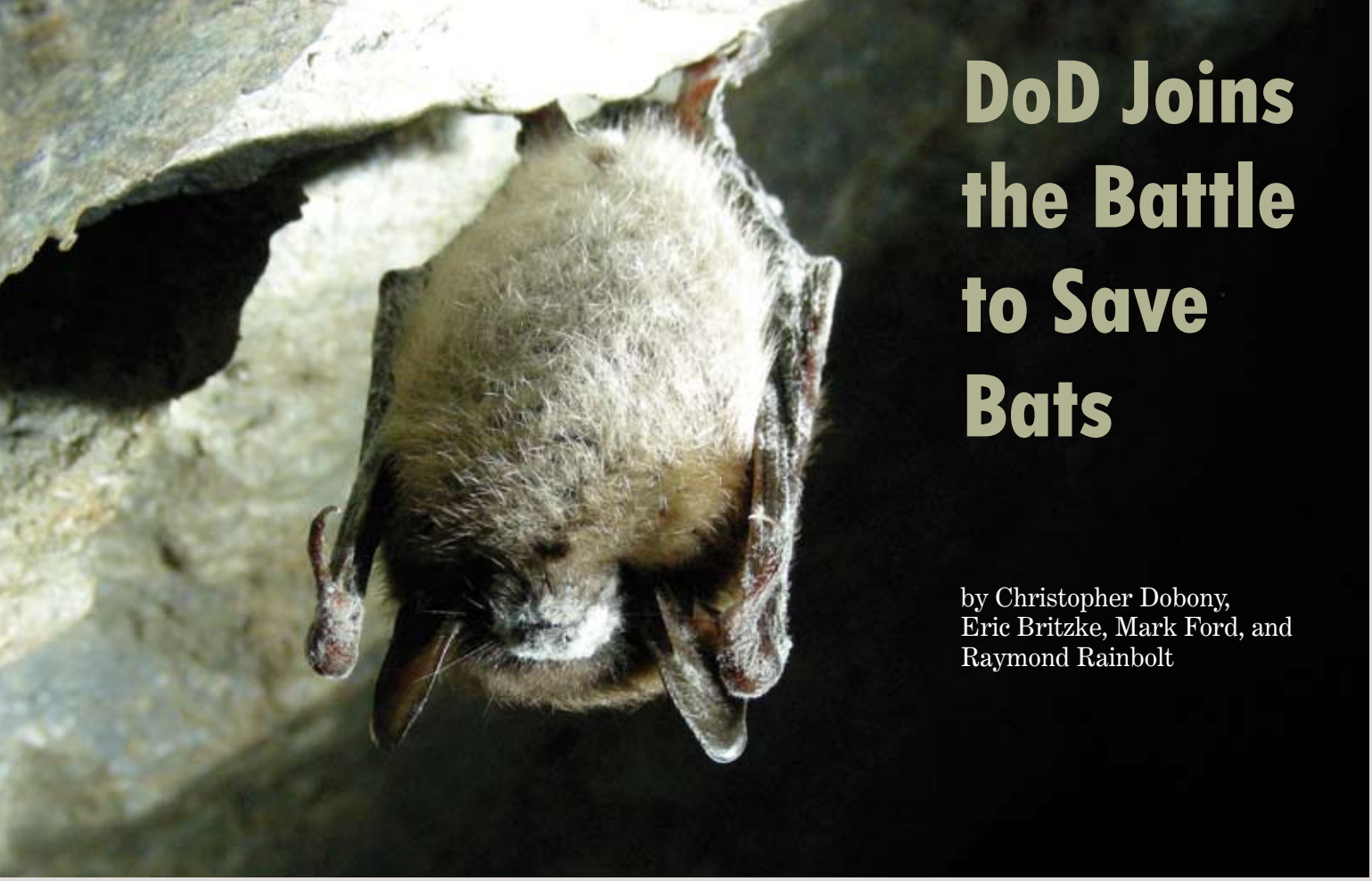
The study findings will support DoD natural resources managers and environmental specialists by providing baseline data on the health of amphibian populations. They will also be incorporated into the emerging disease mapping project, helping researchers look at national patterns and trends of surveyed 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.*

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

White-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 griescens*), 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 batknown 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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(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

The 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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(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

The 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

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.*

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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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.

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.

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.

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.

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

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 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.

For more information, see http://sesc.usgs.gov/freshwater_fauna/okaloosa_darter.html.

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

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Defending Mussel Populations on Military Lands

Taking the Initiative on Managing Species at Risk

by Eric Wolf and Verl Emrick

Healthy 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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(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.

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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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.*

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