PROCEEDINGS

FROM THE

SYMPOSIUM AND WORKSHOP

ON

THREATENED, ENDANGERED, AND AT-RISK SPECIES (TER-S) ON DOD AND ADJACENT LANDS

7-9 JUNE 2005
BALTIMORE, MARYLAND

ACKNOWLEDGEMENTS

The TER-S Symposium and Workshop sponsors wish to acknowledge the input of the event's Steering Committee and Workshop participants, without whom this event and these proceedings would not be possible:

Dr. Robert Holst (DoD SERDP), Mr. Stephen Hodapp (COE, ERDC), Mr. L. Peter Boice (DoD Conservation), Ms. Pamela Behm (DoD Legacy-CTR), Mr. Bill Woodson (U.S. Army-CTR), Dr. Dan Friese (U.S. Air Force, AFCEE), Ms. Lorri Schwartz (U.S. Navy/NAVFAC), Ms. Heidi Hirsh (U.S. Marine Corps), Mr. Lewis Gorman (U.S. Fish and Wildlife Service), Dr. Bea Van Horne (U.S. Forest Service), Mr. Paul Dresler (USGS), Dr. John Weins (The Nature Conservancy), Dr. Reed Noss (University of Central Florida), Dr. Joan Walker (U.S. Forest Service), Dr. Peter Dratch (National Park Service), Mr. Bruce Rittenhouse (National Park Service), Ms. Rachel Muir (USGS), Mr. Tim Hayden (U.S. COE), Mr. Tom Heffernan (Eglin AFB), Dr. David Tazik (U.S. COE), and Dr. Kurt Fristrup (Cornell Laboratory of Ornithology).

Organizers also wish to thank all the plenary and technical session speakers, who are identified in Appendix C and Appendix D, and all technical session chairs, who are identified in Section 3.2 of these proceedings.

Finally, the sponsors also acknowledge the assistance of individuals from HGL, Inc., including Ms. Alison Dalsimer, project manager, Ms. Alicia Shepard, Mr. Sean Donahoe (Marstel-Day, LLC), Mr. John Thigpen, Dr. Leslie Orzetti, Ms. Jenny Rusk, Ms. Katharine Kerr, Ms. Veronica Rice, and Mr. Stephen Jiang.

For more information on the TER-S Symposium and Workshop, please visit www.serdp.org/tesworkshop.

These proceedings were authored by Ms. Alison Dalsimer and Ms. Alicia Shepard of HGL, Inc., and Mr. Sean Donahoe of Marstel-Day, under Huntsville COE contract number DACA87-05-H-001. These proceedings were produced by HGL in September 2005 under DoD Legacy Resource Management Program project number 05-242.

ACRONYMS and ABBREVIATIONS

BCV – black-capped vireo
BLM – Bureau of Land Management
CERL – Construction Engineering Research Laboratory (a COE lab)
COE – Corps of Engineers, U.S. Army
DENIX – Defense Environmental Information Exchange
DoD – Department of Defense
DPS – distinct population segments
ELISA – Enzyme-Linked Immunosorbent Assay
ERDC – Engineer Research and Development Center
ESA – Endangered Species Act
GARP – Genetic Algorithm using Rule-set Prediction
GCPEP – Gulf Coastal Plain Environmental Partnership
GCW – golden-cheeked warbler
GIS – Geographic Information System
INRMP – Integrated Natural Resources Management Plan
Legacy – DoD Legacy Resource Management Program
LIDAR – Light Detection and Ranging
NBII – National Biological Information Infrastructure
NCCP – Natural Community Conservation Planning
NGO – nongovernmental organization
NIFC – National Interagency Fire Center
NPS – National Park Service
NRCS – Natural Resources Conservation Service
PIT – passive integrated transponder
R&D – research and development
RCW – red-cockaded woodpecker
RIFA – red imported fire ant
SEMP – SERDP Ecosystem Management Project
SERDP – Strategic Environmental Research and Development Program
TER-S – threatened, endangered, and at-risk species
TES – threatened and endangered species
TNC – The Nature Conservancy
URTD – upper respiratory tract disease
USDA – U.S. Department of Agriculture
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
USGS – U.S. Geological Survey

EXECUTIVE SUMMARY

The Department of Defense (DoD) utilizes nearly 30 million acres of land and thousands of square miles of air and sea space to conduct missions vital to our national security. These same lands and sea space provide habitat for a great diversity of plants and animals, some of which are found only within DoD stewardship. This creates a challenge: how to effectively use lands, air, and sea for national security missions while simultaneously conserving species protected by the Endangered Species Act and those at risk of needing such protection.

In a collaborative effort, the Strategic Environmental Research and Development Program (SERDP), U.S. Army Corps of Engineers Engineer Research and Development Center (ERDC), and DoD Legacy Resource Management Program (Legacy) cosponsored the *Threatened, Endangered, and At-Risk Species (TER-S) on DoD and Adjacent Lands Symposium and Workshop* held 7-9 June 2005 in Baltimore, Maryland. The objectives of this Symposium and Workshop were to: 1) present the most up-to-date information on government and academic TER-S research relevant to DoD, 2) stimulate collaboration and foster partnerships among participants, and 3) identify additional areas of research needed to address TER-S and associated habitat issues facing DoD and other federal land-managing agencies.

The TER-S Symposium and Workshop marked the first time that a broad spectrum of researchers from diverse backgrounds and agencies/organizations gathered to share their mutual concerns and issues regarding the need to maintain TER-S and their habitats. Many participants established new partnerships through which they can work to better integrate research, management, and collaborative initiatives to benefit TER-S. Participants included researchers and managers from DoD and all the military services, the U.S. Fish and Wildlife Service, U.S. Geological Survey, National Park Service, U.S. Forest Service, and various nonprofit organizations, state agencies, universities, and private consulting firms.

The two-day symposium consisted of two plenary sessions and a comprehensive technical program. The Symposium's five distinguished plenary speakers all highlighted the central role of partnerships for ongoing and future threatened and endangered species initiatives. The technical program highlighted research on mammals, birds, reptiles, amphibians, freshwater fish, invertebrates, and vascular plants. The eight technical sessions were:

- *Planning and Mitigation*
- *Habitat Modeling and Assessment*
- *Invasive Species: Red Imported Fire Ants*
- *Inventory and Monitoring* (two sessions)
- *Habitat Management and Manipulation*
- *Impact Assessment*
- *Species and Habitat Conservation*

The half-day workshop that followed was an invitation-only event designed to identify current knowledge gaps relevant to DoD's high priority TER-S and associated habitats, and create a framework for specific research and development needs. The three breakout groups focused on *Inventory and Monitoring*, *Invasive Species and Species Interactions,* and *Technology Transfer*.

Workshop discussions elucidated a number of needs, from promoting a regional conservation approach to facilitating information exchange among the many stakeholders. Section 4 discusses these results.

These proceedings present and analyze issues raised throughout the TER-S Symposium and Workshop, including the plenary sessions, technical sessions, panel discussions, and workshop discussions. Key issues, current science, needs and gaps, and future directions are highlighted in Section 5, with needs indicating short-term objectives and future directions suggesting long-terms actions. Suggestions for directing future efforts and resources ranged from developing and validating cost-effective remote sensing monitoring networks, to conducting species and habitat monitoring at multiple scales, to using Web-based collaborative tools so stakeholders can better share information. Section 6 summarizes the overarching recommendations distilled from the entire event. These included:

- Researching basic species life history and improving basic biological information
- Increasing proactive conservation efforts for species at risk and invasive species
- Developing more consistent peer-review data standards and monitoring protocols
- Improving predictive models to support management decisions
- Focusing on protection of endangered ecosystems rather than individual species, and
- Improving information-sharing among stakeholders.

Ultimately, this Symposium and Workshop was the first step toward a long-term effort for all stakeholders to work together to help DoD fulfill its military training and testing mission while protecting the valuable resources with which it is entrusted, and on which it depends.

These proceedings complement a 3-CD set containing electronic copies of all plenary and technical presentations. Further information on the event and follow-on activities is available at http://www.serdp.org/tesworkshop/.

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1.0 INTRODUCTION

The Department of Defense (DoD) utilizes nearly 30 million acres of land and thousands of square miles of air and sea space to conduct missions vital to National Security. Due to the restricted access to military installations by the general population, burning and other disturbances, and lack of development, these same lands, air, and sea space serve as habitat for a great diversity of plants and animals—some of which are found only in areas within DoD stewardship. This unique situation creates a significant challenge for DoD: how to effectively use lands, air, and sea for national security missions while simultaneously managing and conserving species protected by the Endangered Species Act (ESA) and those at risk of needing such protection.

1.1 ENDANGERED SPECIES AND SUPPORT OF THE MILITARY MISSION

With approximately 320 threatened and endangered species (TES) and nearly 550 species at risk, DoD lands support more species in need per acre than any other federal agency (Table 1). DoD also spends more per acre on endangered species management per year than any other federal land management agency. Of the major land managing agencies, DoD spends approximately $1.70 per acre, while the U.S. Fish and Wildlife Service (USFWS) spends approximately $0.85 per acre, the U.S. Forest Service (USFS) and National Park Service (NPS) spend approximately $0.11 per acre, and the Bureau of Land Management (BLM) spends approximately $0.07 per acre. Over the last 15 years, DoD has spent a total of nearly $400 million on management of TES (NatureServe 2003).

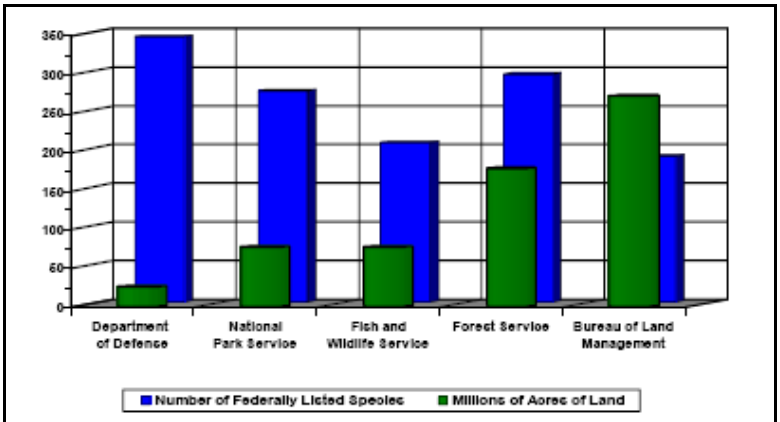

Table 1. Number of listed TES per agency relative to millions of acres of lands managed**.**

The DoD is required to manage TES in compliance with existing environmental laws and policies while also maintaining their lands for long-term sustainability to ensure that soldiers, sailors, airmen, and marines can train as they fight and continue to test weapons systems under realistic conditions for years to come. DoD can achieve these apparently disparate goals only through internal collaborative efforts with military trainers and testers and with its many partners and stakeholders—especially other land and resource management agencies and organizations.

1.2 IMPORTANCE OF ADJACENT LANDS AND PARTNERSHIPS

DoD lands often are seen as "islands of biodiversity" in otherwise developed areas. For example, Camp Pendleton in southern California offers the only undeveloped shoreline between Los Angeles and San Diego,, as well as some of the best remaining habitat for such TES as the California least tern, Western snowy plover, light-footed clapper rail, and tidewater goby.

To avoid creating additional situations such as that of Camp Pendleton, DoD works with managers and owners of lands adjacent to military installations to manage habitats cooperatively through an ecosystem approach. This approach seeks to manage threatened and endangered species and their habitats by looking beyond local jurisdictional boundaries.

In concert with a variety of federal, state, tribal, local, and private partners, DoD has participated in a number of regional ecosystem management programs. These partnership-based management programs have played an integral role in protecting and conserving many species. Current partnership efforts span the country and are as diverse as the ecosystems themselves.

- At Fort Bragg in North Carolina, the Army has partnered with adjacent land owners in creating corridors to connect disparate populations of red-cockaded woodpeckers (RCW) and manage those birds as a single, larger population.[1]

- In Colorado, DoD has funded a Front Range ecosystem management project in cooperation with The Nature Conservancy (TNC),[2] and is working within the Cooperative Ecosystem Studies Unit program to develop strategies for minimizing pressures brought on by population expansion and commercial development.[3]

- In the desert southwest, DoD is working with the BLM, NPS, U.S. Geological Survey (USGS), USFWS, California State Parks and Fish and Game Department, California Desert Conservation Area, and numerous private groups and individuals to better protect the federally endangered desert tortoise and habitat on which it depends.[4]

- At Eglin Air Force Base in Florida, natural resource management personnel have developed a program that former Interior Secretary Bruce Babbitt called "the best example of ecosystem management, partnerships and good science he had ever seen, and 'a model for the nation.'"[5]

These cooperative programs with adjacent land partners illustrate how species and habitat management across jurisdictional boundaries have benefited the species, leveraged resources, and assisted in achieving the common goals of the partners. Clearly, land areas adjacent to DoD lands are an important part of threatened and endangered species management.

[1] http://aec.army.mil/usaec/natural/bragg-factsheet.pdf
[2] www.dodlegacy.org. Title: *Develop a Landscape Assessment for a Portion of Colorado Front Range*
[3] Cooperative Ecosystem Studies Units: http://www.cesu.org/
[4] As a result of this effort, partners have created the Mojave Desert Ecosystem Program—a spatial database for the ecoregion: http://www.mojavedata.gov/
[5] http://www.eglin.af.mil/em/virtualtours/babbitt/index.htm

1.3 SYMPOSIUM AND WORKSHOP OBJECTIVES

The symposium's objective was to define and evaluate TES research relevant to DoD, present the most up-to-date information on government and academic TES research relevant to DoD, and stimulate collaboration and foster partnerships among participants. The two-day event consisted of two short plenary sessions and a comprehensive technical program. The technical program consisted of eight sessions addressing a variety of species, ecosystems, technologies, and policy issues. Current and recently completed research on mammals, birds, reptiles, amphibians, freshwater fish, invertebrates, and vascular plants were highlighted.[6]

The half-day workshop that followed was an invitation-only event designed to identify current gaps and additional areas of needed research relevant to TES and associated habitats facing DoD and other federal land managing agencies. Its goal was to create a framework from which specific research and development (R&D) needs could be developed.

2.0 BACKGROUND

The impetus for the TER-S Symposium and Workshop stemmed from the DoD/USFWS Endangered Species Roundtable and its desire to increase partnerships among federal land management agencies. The TER-S Science Forum, a Roundtable Working Group, focuses on identifying and addressing research needs relevant to TER-S. Its members were intimately involved in planning this event.

2.1 SPONSORSHIP

Primary sponsors of the TER-S Symposium and Workshop included the Strategic Environmental Research and Development Program (SERDP), the U.S. Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory (CERL), and the DoD Legacy Resource Management Program (Legacy). Brief descriptions of their respective missions follow.

- SERDP is DoD's corporate environmental R&D program, funding efforts in the areas of Sustainable Infrastructure, Environmental Restoration, Weapons Systems and Platforms, and Munitions Management. Sustainable Infrastructure encompasses natural resources, cultural resources, and facilities. SERDP's role in conserving TES is through innovative research.[7]

- ERDC is the U.S. Army Corps of Engineers (COE) environmental research and development support arm. Through its seven laboratories, ERDC develops innovative science and technology solutions to support warfighting, infrastructure, environmental, and disaster operations. As one of those laboratories, CERL focuses its efforts on acquisition and revitalization, installation operations, and military lands.[8]

[6] See appendices for agenda, biosketches, and presentation abstracts.
[7] www.serdp.org
[8] http://www.erdc.usace.army.mil/

- DoD's Legacy Program balances the intensive use of DoD lands for military training and testing with the protection of its natural and cultural resources. Legacy's goal is to preserve the military's ability to train and test, while meeting human health, safety, and aesthetic needs. It does this by conserving resources proactively, so as to better prevent their degradation or destruction, and by joining with public and private partners to achieve common conservation goals.[9]

2.2 STEERING COMMITTEE

The TER-S Symposium and Workshop Steering Committee comprised representatives from the DoD SERDP and Legacy Programs, military services, COE, USFWS, USGS, USFS, University of Central Florida, and TNC. The committee's purpose was to act as an information source and guiding force for agenda development. Specifically, members were asked to identify and help solicit plenary speaker participation, identify specific speakers or session topics that might be relevant, and distribute the call for abstracts through their respective organizations. Most members participated in the half-day workshop that followed the symposium.

2.3 PRE-WORKSHOP PARTICIPANT PREPARATION

To prepare participants for the workshop portion of this event, they were provided with a read-ahead package of "thought stimulators," including:

- Responses from pre-symposium registration questions, *What challenges does the DoD see with respect to threatened, endangered, and at-risk species (TER-S) and training?* and *What research and monitoring issues facing TER-S do you feel are most important?*[10] (See Appendix F)

- Targeted questions broken into several different categories focused on:
  - Effects of military training on TES
  - Conflicts with TES management and installation missions
  - Habitat management and restoration
  - Real-time and long-term monitoring
  - Interactions with invasive species
  - Standardization of protocols for monitoring and conservation, and
  - Sustainability of resources.

- A matrix to capture and organize ideas on key issues, the current state of the science, needs/gaps, and potential solutions/R&D topics for each of the eight technical sessions.

- Outline for the anticipated TER-S Symposium and Workshop proceedings document.

Members were also asked to reflect on a variety of challenges, including: funding obstacles, communication difficulties within the research community, training restrictions, the paucity of real scientific evidence regarding training impacts, managing competing land uses, effectively

[9] www.denix.osd/legacy
[10] See Appendix 8.6 for responses to the questions posed.

creating partnerships to manage species across jurisdictional boundaries, and the public's perception of DoD's mission and its impact on TES.

3.0 SYMPOSIUM AND WORKSHOP

Mr. Bradley Smith, SERDP Executive Director, opened the symposium by welcoming the environmental professionals and researchers in attendance. He and Mr. Steve Hodapp, COE, outlined the event's goals and the technical session objectives, introduced the plenary speakers, and highlighted the desired outcomes, including increased collaboration, information exchange, technology transfer among participants, and identification of current TER-S research initiatives and future research requirements. They noted that the Endangered Species Act was not controversial at its outset. However, in the early 1990s, Fort Bragg and Fort Stewart received jeopardy opinions for the RCW. Since then, TES have remained a key issue for DoD, and partnerships play an essential role in this area.

3.1 PLENARY SPEAKERS

The five plenary speakers discussed issues related to TER-S from a variety of perspectives. All highlighted the central role of partnerships for ongoing conservation initiatives. This theme set the stage for later technical sessions and panel discussions,, as well as individual discussions.

Mr. Alex Beehler (Assistant Deputy Under Secretary of Defense for Environment, Safety, and Occupational Health) discussed the high quality of habitats and high diversity of species on DoD installations, many of which are located in rapidly urbanizing areas. This is especially true in coastal and other low elevation habitats, where many species thrive. He stressed the need to conserve species and their habitats not only for conservation purposes, but also for sustaining the military mission, stating that DoD takes both its training and testing mission and its conservation responsibilities seriously. Each of the 368 installations containing significant natural resources are required to maintain an Integrated Natural Resources Management Plans (INRMP), approved by the USFWS and state wildlife agency, to help military land managers assess and manage natural resources—actively minimizing military impacts to those resources whenever and wherever possible. DoD actively practices conservation and funds conservation-related research, because it is important for soldiers to train in realistic environments (i.e., train as they will fight).

He went on to say that DoD has taken several actions to help meet its environmental management goals. For example, from an organizational perspective, DoD has integrated environment, safety, and occupational health into one office. This means that the military can now manage environmental matters from design to disposal, which represents an important new directive and policy for military operations. Additionally, DoD has pushed for and is now acquiring congressionally-funded conservation buffer zones. These buffer zones provide increased habitat connectivity for the diverse species residing on DoD installations and adjoining lands. In addition, they assist in combating encroachment and the associated interferences and expenditures. DoD also is exploring conservation on adjacent farm lands, recognizing that they have great potential both for buffering DoD installations and for improving sustainable agricultural practices and land use.

In conclusion, Mr. Beehler highlighted how focused research on RCWs and partnerships among installations in the Southeast has reduced training restrictions by over 80,000 acres on Army lands, while increasing the number of potential RCW breeding groups by 45% from 1997 to 2003.

Dr. J. Michael Scott (USGS, Leader, Idaho Cooperative Research Unit, Professor of Wildlife, University of Idaho, Moscow) addressed the need to renew the conservation promise envisioned by the ESA. He began with a retrospective examination of the Act at 30 years: What are we protecting and why? What have we learned? Where do we go from here? His talk highlighted the need to synthesize knowledge gained in biology, ecology, economics, and law; provided an overview of moral, legal, and biological arguments for protecting different levels of biological organizations; and evaluated opportunities for conservation policies and prospects through partnerships.

Using data from October 2003, Dr. Scott stated that of the 516 animal and 744 plant species in the U.S., 78% are categorized as endangered, implying a failure to achieve one of the ESA's primary goals, preventing endangerment, since each of those species passed through a stage at which they were threatened before they became endangered. He continued the theme stating that most species listed today experienced substantial delays on the path to protection with agencies taking an average of nearly 11 years to list any given species. Further, in the Lower 48 states, 27 biological regions have lost more than 98% of their original area since European settlement (e.g., Palouse prairie, longleaf pine, low elevation native grasslands), and 371 plant communities are considered rare or threatened (e.g., lodge pole pine woodlands and ponderosa pine woodlands).

To put current efforts in context, Dr. Scott described the current state of conservation areas, most of which are on the least productive of our nation's soils and at the highest elevations, though many species (e.g., reptiles and amphibians) require primarily lower elevational habitat.

Regarding the ecological context of National Wildlife Refuge lands, Dr. Scott stated that 172 refuges (nearly 40%) have greater than 50% anthropogenic cover within 10-50 kilometers (km) of refuge boundaries. Thirty-four refuges (just over 7%) have greater than 20% of the land within 10 km of refuge borders in urban cover. Twenty-four refuges (just over 5%) have greater than 20% of the land within 50 km of refuge borders in urban cover. Of the 245 natural resource parks in the contiguous United States, 40% are less than 1,000 hectares, and 50% are split into more than one unit (e.g., the Nez Perce National Historic Park's 860 hectares is split into 38 subunits).

Regarding the ecological context of DoD lands, he noted that 90% are found in 14 ecoregions and over 50% are found in four ecoregions (i.e., Mojave Basin and Range, Central Basin and Range, Sonoran Basin and Range, Chihuahuan Desert). Thirty percent of the 729 DoD installations contain species at risk (523 different species, two-thirds of which are plants). At least 82 at-risk species have at least half their populations on DoD lands, and 24 of these are known to exist only on DoD lands (10 on San Clemente Island alone). San Clemente Island is considered the most environmentally distinct coastal island owned by the United States. Of the top 21 installations with the greatest TER-S density, eight are in Hawaii, four in California, and four in Florida—areas where urbanization and the spread of invasive species are most significant.

Dr. Scott then shared his perspective on emerging TER-S challenges, including global climate change, finding and promoting compatible land-use practices on lands adjoining DoD facilities, creating new and nontraditional public and private partnerships, and viewing DoD lands in the context of a broader conservation landscape. He also outlined the following four opportunities for DoD: 1) partnering with USFWS, TNC, and others (e.g., NatureServe and USFWS are helping DoD identify "species at risk" on and adjacent to its military lands); 2) establishing new protected areas adjacent to DoD properties (e.g., Army is working with landowners near Fort Bragg to establish conservation easements); 3) partnering with adjacent land owners to promote compatible uses, such as ranching versus development (USFS is partnering with DoD in southeastern United States); and 4) making San Clemente Island an ESA flagship.

In summary, Dr. Scott noted that DoD lands are a major contributor to America's Conservation Landscape 2076. However, recovery activities are under-funded by a factor of two or more and suffer from Linnaean,[11] Wallacean,[12] and Grinnellian shortfalls.[13] In addition, large numbers of endangered species are conservation reliant and will require ongoing management after delisting. Further, the time to save a species is when it is common, although we are not getting ahead of the extinction curve. Umbrella agreements with state or federal agencies can be used to decrease red tape, time, and money for private landowners. An ESA database that is comprehensive, transparent, and consistent with the Federal Register is needed to coordinate efforts.

Dr. Scott asked the audience to examine scientific goals: Are we trying to save all species? Is that realistic? How long will recovery take? Are we facing the realities of long-term costs? In the end, he challenged attendees to continue high-level scientific study, work collaboratively, and address the difficult questions facing resource managers and researchers today and in the future.

Dr. Kurt Fristrup (Assistant Director, Bioacoustics, Cornell Laboratory of Ornithology) began his presentation by stating that extinctions are tragedies from many perspectives: biochemical factories destroyed before they are inventoried, ecological links severed before their consequences are known, evolutionary chapters burned before they can be read. He then noted that no nation has lost more species of birds in the past 25 years than the United States, a fact published in the issue of *Science* that celebrates the rediscovery of the ivory-billed woodpecker.

In every sector of our society, technology is bringing significant advances in productivity. These advances provide opportunities for more effective conservation. While there are a number of factors that limit bird population and trend estimate accuracy (e.g., accessibility, roadside bias), bird-watching protocols can be used to develop rigorous statistical estimates (e.g., accuracy). Dr. Fristrup presented examples of how innovative technologies can assist land managers, describing

[11] Linnaean taxonomy classifies living things into a hierarchy, starting with *domains* or *kingdoms*. For a complete definition, see http://en.wikipedia.org/wiki/Linnaean_taxonomy.

[12] Wallacean shortfall refers to Alfred Russel Wallace's theory that the key to understanding and conserving biological diversity is a thorough knowledge of the geography of imperiled species, and that the critical paucity of such information (the Wallacean shortfall) remains one of the most important challenges for conservation biologists.

[13] Joseph Grinnell, first director of the Museum of Vertebrate Zoology, developed a detailed protocol for recording field observations. For further detail, see http://www.mip.berkeley.edu/mvz/history/GrinnellianMethodology.html.

how he and his colleagues adapted marine digital audio modules to terrestrial habitats by developing cost-effective bioacoustic sensors. Their goals in modifying this technology included:

- Extend monitoring into areas and habitats that are difficult to access
- Provide monitoring capabilities for species that are not readily censused by other means
- Acquire and process long-term recordings to document factors affecting acoustic detectability
- Amplify the value of citizen science and long-term data sets through double sampling, archival recordings, and cross-validation
- Produce systems that can conduct distance sampling (line transects and point sampling).

Using acoustic instrumentation and software, he and other researchers have been able to monitor birds in inaccessible areas such as DoD impact areas, quantify detectability using long-term recordings, use localization to quantify range of detection and perform double sampling, acoustically monitor migration and stopover habitats, and make the connection to the ivory-billed woodpecker. He riveted the audience with recordings of the ivory-billed woodpecker (one from 1930 and another from 2005). The 2005 sounds were recorded and automatically detected using technology developed with SERDP funding to monitor black-capped vireos (BCV) and golden-cheeked warblers (GCW) in inaccessible areas of Fort Hood in Texas, including the live-fire and artillery impact areas. The autonomous digital recording technology is applicable to any acoustically active animal, especially those living in restricted or prohibited access habitats.

Dr. Fristrup concluded by stating that we, as a society, must go beyond protecting endangered species and take measures to keep common birds common, avoiding both the risk and the regulatory burdens that result from unchecked declines. We must do this by developing technologies and partnerships that enable tech transfer and coordination of monitoring efforts.

Mr. Dan Ashe (Science Advisor to the USFWS Director) provided both his agency's and his personal perspective regarding the need for TES conservation, identifying key issues and charging the audience to bring research and management priorities back in line with one other. Opening with a passage from *A Sand County Almanac* by Aldo Leopold, Mr. Ashe described the need for scientists and policy makers to "think like a mountain" in successfully conserving imperiled species.

He continued by drawing on a speech from Madeleine Albright,[14] comparing the conservation of TES to her "great axes of evil: poverty, ignorance, and disease." By losing species at an alarming rate, Ashe likens poverty to the loss of future generations' inheritance of a world rich with species. He used the world's struggle against ignorance to describe how, after decades of persistence by scientists, wetland conservation has become more common, with the public being better educated and less apathetic. He correlated the final axis of evil, disease, to poverty and

[14] Former U.S. Secretary of State.

ignorance. He stated that we need to educate the public that through species conservation there is greater potential for medicinal discoveries and an increase in natural capital possibilities. Critical to defeating these axes of evil, he continued, is creating partnerships.
The greatest successes to date in TES conservation have been through collaborative efforts among federal agencies, states, tribes, zoos, universities, conservation organizations, private landowners, and others. Of particular challenge to these efforts has been obtaining timely and relevant scientific information, thereby creating a gap between research endeavors and management pursuits. To bridge this gap and make partnerships more effective, research and management must be linked by explicitly stated and testable assumptions.

To better achieve this more practical science, the USFWS is renewing its commitment to scientific excellence by defining six Fundamental Science Practices:

1. Landscape Conservation Assessment
2. Adaptive Management
3. Structured Decision Support
4. Conservation Genetics
5. Ecological Forecasting
6. Peer Review

Additionally, beyond the recommitment to these practices, scientists and managers alike must begin to develop scientific information to guide management in the wake of complex and large-scale environmental change, and to begin to truly "think like a mountain."

Mr. Ashe went on to say that the most pressing of current large-scale challenges to conserving ecological function are climate change, water conservation for ecological function, invasive species, and biotechnology. By working together to better understand and overcome the challenges posed, the conservation of TES will become a less daunting task.

In closing, Mr. Ashe challenged the audience to get organized, to identify and apply better science, to adhere to fundamental science practices, and to recognize and deal with those major challenges that will define our ability to succeed throughout this century and into the next. If we accomplish this, he stated, we will "think like a mountain" and be better stewards of our world.

Colonel Wayne Thomas (U.S. Army, Office of the Director of Environmental Programs) began by stating unequivocally that the Army values and loves its land. Installations, he stated, are the DoD's flagships and that only by conserving its resources can the military sustain its mission and secure the nation's future.

Colonel Thomas then outlined Army's strategy for the environment, which is to ensure that present and future soldiers have the land, water, and air resources to train; a healthy environment in which to live; and the support of local communities and the American people. The Army's motto "Sustain the Mission – Secure the Future" means that simply complying with environmental regulations will not ensure sustainability. At its core, Army's purpose—its reason for existence—is to fight wars. To do this, soldiers must train as they fight. This means an intensive use of the land, and sometimes there are conflicts in land use.

The Army's training mission is constantly changing. In addition to warfighting, the Army is a conservationist working in partnership with other federal agencies (USFS, NPS, USFWS, BLM, USGS). Through policy, guidance, management, technology, and new initiatives (e.g., Army Compatible Use Buffers), Army strives to benefit from the triple bottom line of "Mission – Environment – Community." As examples of how Army works simultaneously to achieve military readiness and conservation, Colonel Thomas highlighted the following three successful examples of how knowledge gained from research and joining with conservation partners resulted in benefit to both the species and the mission.

- When the RCW was listed as an endangered species, several Southeastern installations lost huge parcels of available training area. Due to years of extensive research, much of it funded by the Army, the restricted buffer area around RCW cavity trees was reduced from 200 feet to 50 feet. Army is continuing its efforts toward achieving a no-buffer status and protecting just the cavity trees themselves. Doing so will enable significantly expanded training maneuverability.

- At Fort Hood in Texas, the presence of endangered BCVs and golden-cheeked warblers significantly restricted land use and training activities. As a result of integrating natural resource management activities with a number of research programs, the installation's restricted lands went from 72,400 acres in 1994, to 51,500 acres in 2003, to just 9,500 acres in 2005. While this is still a significant amount, it represents a fraction of the area originally under full restriction and, thus, a successful outcome.

- The Hawaiian Islands have significant TER-S issues. At Makua Military Reservation, the presence of 33 listed species resulted in severe restrictions to training times and durations, types of training activities, access to land, and a major administrative burden. As a result, Makua was voluntarily shut down for more than a year during Section 7 consultation and, although reopened, the number of live-fire events is now restricted to fewer than the Army requires.

In summary, Colonel Thomas clearly articulated the Army's unique pressures in trying to maintain its training and weapons testing mission while managing for conservation of threatened and endangered species. He stated that sustainability and strengthening community partnerships are the foundation of Army's efforts, and he stressed the need for building those partnerships, having conservation organizations play a role in military readiness, and looking to adjacent lands to ease the Army's conservation burden. He charged the audience with thinking of ways that research can benefit both species and mission requirements.

3.2 TECHNICAL SESSIONS

The symposium technical sessions focused on species and habitat research, military training impacts to TER-S, and "good news protection" stories at several installations. Management issues for several species were presented, including the gopher tortoise, least tern, Western snowy plover, BCV, Pacific salmon, Indiana bat, and invasive red-imported fire ant (RIFA). Each technical session was followed by a panel discussion consisting of all speakers and the session chair. The goal of these panels was to foster open dialogue regarding issues of mutual

research and management concern across agencies, organizations, and individuals. Brief descriptions of each technical session and identification of session chairs follow.

1A. Planning and Mitigation
(Chair: Bill Woodson, U.S. Army)

Through presentations on research and tools that support planning and mitigation for TER-S, this technical session highlighted how different agencies take similar paths to achieve their goals. These paths range from the use of metrics to assess resiliency to information sharing through databases to the role of range-wide recovery. Planning and mitigation measures for rare plants and other TER-S were discussed.

1B. Habitat Modeling and Assessment
(Chair: Joan Walker, U.S. Department of Agriculture [USDA] Forest Service)

This technical session presented numerous monitoring technologies and landscape-scale models that have been implemented to identify and evaluate habitat for TER-S. Presentations focused on developing habitat and population models that address key management questions and directly support the conservation of "endangered ecosystems." A wide range of statistical and theoretical models have been developed, principally at a landscape scale, to assess impacts to listed species. Talks stressed the importance of improving the accessibility, quality, and long-term ability to use remote sensing data to track and model habitat quality and change. Other emphasized topics included validation of remote sensing data (ground-truthing) and making habitat models/monitoring more relevant to management issues and questions.

2A. Invasive Species: Red Imported Fire Ants
(Chair: Dan Friese, U.S. Air Force)

Red imported fire ants were introduced to the United States in the 1930s. Populations of this invasive species have since spread rapidly, and now there are concerns that the species will expand into the west coast and Hawaii. This technical session described efforts to prevent the introduction of RIFA and other invasive species, control RIFA populations, and manage their impacts to sensitive species and cave ecosystems. Presentations highlighted the huge potential negative impact that invasive species can have on TER-S.

2B and 3B. Inventory and Monitoring (parts 1 and 2)
(Chair: Paul Dresler, USGS)

This two-part technical session discussed cutting-edge inventory and monitoring technologies,, as well as tools to determine presence/absence and estimate population abundance. Presentations focused on addressing limitations of current monitoring programs for listed and rare or illusive species. Often monitoring programs are not consistent and lack relevancy to key management questions posed by land managers. Monitoring programs recently developed and implemented for the BCV, desert tortoise, and Indiana bat represent the latest attempts in applying innovative technologies to address key management questions. Topics of discussion included protocol development, indicator variables/species monitoring, index versus inferential approaches, remote

auditory sampling devices, thermal infrared videography sampling, implanted radio telemetry, microhabitat monitoring, presence/absence monitoring, real-time remote data collection and analysis, and population monitoring.

3A. Habitat Management and Manipulation
(Chair: Peter Boice, DoD)

This technical session showcased habitat management and manipulation efforts undertaken to improve the viability and recovery of a variety of species, including tortoises, birds, fish, and plants. In addition, the secondary impacts of habitat management and manipulation for particular TER-S (e.g., prescribed burning for RCWs) on other species (e.g., gopher tortoise) was discussed.

4A. Impact Assessment
(Chair: Steve Hodapp, COE)

Impact assessment directly affects military testing and training levels and is a critical component of consultation with the USFWS. Although it is challenging to assess impacts without adequate baseline information on species, this technical session introduced several technologies and tools that have been applied in the field to assess military (e.g., training disturbance, military-unique compounds) and non-military impacts (e.g., stream barriers).

4B. Species and Habitat Conservation
(Chair: Reed Noss, University of Central Florida)

Ecosystem management is an important tool for species and habitat conservation. This technical session discussed species at risk on DoD lands, use of databases to track trends, metapopulation genetic analyses, nest protection measures, and implications associated with discovering a new species. Species and habitat conservation for certain ecosystems (e.g., karst) can present unique challenges that require tailored approaches.

3.3 WORKSHOP

The workshop that followed the symposium was an invitation-only session of chairs, steering committee members, and other select invitees from partnering organizations. The group consisted of at least one representative from DoD, the military Services, COE, USFWS, NPS, USGS, TNC, and the Cornell Lab of Ornithology.

The group's charge was to summarize the current state of the science; determine the top priority, short- and long-term R&D TES-related needs based on priorities identified during symposium presentations; and discuss future directions. Three key topical areas surfaced from the symposium: *Inventory and Monitoring, Technology Transfer,* and *Invasive Species and Species Interactions.* The 24 invitees self-selected evenly among the three breakout groups. Each group provided a summary of their discussions, identifying their top priorities.

4.0 WORKSHOP RESULTS

This section presents results from the workshop breakout groups. Analysis of these results and of those from plenary and technical session presentations is provided in Section 5.

4.1 INVENTORY AND MONITORING

The *Inventory and Monitoring* group focused on promoting a regional approach to monitoring, where "hotspots of endangerment" should be determined.[15] It was thought that these hotspots would help identify where joint relationships and monitoring activities already exist, and partners could encourage collaborative approaches to monitoring and management practices and prioritization of future research. The group also focused on the need for peer reviewed monitoring protocols that are readily accessible to the management community and are designed to provide results that are transferable and translatable across agency lines. Finally, the group discussed the need for basic life history information on TES to be located in a common database, providing all agencies access to the current effective means of conserving individuals and populations.

4.2 INVASIVE SPECIES AND SPECIES INTERACTIONS

The *Invasive Species and Species Interactions* group focused on the need for policy and legislative changes, interagency collaborative opportunities, preventative management, invasive species control, and studies of the impacts of invasive species on ecosystem processes. More proactive and early response funds are needed to manage and control, respectively, at-risk and invasive species. With new policy, these challenges may be included in INRMP in order to qualify for noncompliance funds and help alleviate other funding burdens. This group also emphasized the need for interagency collaboration to help fill information gaps relating to invasive species management, control, and impacts on at-risk species.

4.3 TECHNOLOGY TRANSFER

The *Technology Transfer* group examined the need for information sharing not only within DoD, but across agencies as well. Specifically, they focused on conceptualizing a tool that would enable all stakeholders to share information, collaborate, and leverage limited resources to protect TER-S and endangered ecosystems, particularly at a landscape scale.

Participants identified a need to determine who the overall community of practice would be, and suggested that a DoD liaison attend TES training events and act as a conduit for the transfer of information to other agencies. They also identified a need for Web-based information exchange and an offline database for sensitive information and non-Internet users. With a Web-based information gateway, the group also recognized the need for and solution to public outreach goals of publicizing good news stories about what the DoD is doing, has done, and will do to preserve TER-S.

[15] "Hotspots" refers to areas where the most imperiled regions with the most imperiled species reside.

5.0 ANALYSIS OF ISSUES

The following analysis reflects issues raised throughout the TER-S Symposium and Workshop, including the plenary sessions, technical sessions, panel discussions, and workshop discussions.

5.1 SPECIES AND HABITAT INVENTORY AND MONITORING

Many stakeholders collect data elements that they hope will add to the larger body of inventory and monitoring knowledge for both individual species and their habitats. This knowledge has the potential to fill key data gaps regarding the taxonomy, life history, and geographic distribution of many TER-S and rare species. Unfortunately, for the larger body of knowledge, there is all too often little coordination or consolidation of such data. Central to the ability to inventory and monitor species and habitat are the concept of multiscale monitoring and the availability of cost-effective technologies to achieve this goal. Additionally, the ability to collect meaningful and useful data will depend directly on establishing credible indicators of change, standardized metrics, and validated collection protocols.

5.1.1 Monitoring Technologies

Improvements in monitoring technologies,, as well as automation of data processing, support the implementation of cost-effective species and habitat monitoring networks at various scales. Research projects have demonstrated the promise of this approach in addressing TER-S issues.

Key Issues and Current Science

Limitations and gaps in monitoring technologies prevent their wide-scale application to address TER-S issues. Cost also is an important consideration, as many plant and animal populations on federal lands have not been characterized due to insufficient funding.

Current capabilities range from remote sensing technology to meta-population genetic analysis. Remote sensing LIDAR data can provide high resolution, vegetation structure data for building predictive habitat models and tracking select ecosystem indicators. Acoustic and radio telemetry and passive integrated transponder (PIT) tags allow researchers to monitor the distribution of mobile species, such as fish and birds. With respect to genetic analyses, meta-population approaches have been used to assess TER-S population health, viability, and genetic flow at the landscape scale.

Current Needs and Gaps

Natural resource management requires extensive monitoring data. There is a need to validate inventory and monitoring technologies that provide cost-effective remote sensing data with sufficient resolution to impact management decisions. Specific needs identified include:

- Developing landscape-scale monitoring network technology and innovative inventory techniques that are cost effective and efficient

- Demonstrating and validating inventory and monitoring technologies against known population sizes to establish standards for the data collected using such technologies

- Assessing how well remote-sensing technologies can simulate vegetative cover, structure, and changes relevant to species and habitat inventory and monitoring

- Availability of an alternative source for reasonably priced high-resolution remote sensing data that provides microhabitat and structural vegetation cover data[16]

- Developing and automating data processing tools that translate monitoring data to GIS imagery, in such a way that they are usable by land managers and decision-makers.

Future Direction

The future of monitoring technology lies in developing and validating cost-effective remote sensing monitoring networks for species and habitats in support of assessing landscape-scale changes. Specific approaches to address future needs include:

- Support, maintain, and integrate the use of economical remote sensing technology sources (e.g., LIDAR data may be available in 5 years via satellite)

- Explore potential applications for acoustic technology to monitor TER-S behavior

- Conduct pilot-scale studies to assess the potential application of new and emerging DoD technologies for multiscale monitoring applications relevant to TER-S.

5.1.2 Multiscale Monitoring

Effective TER-S species and habitat monitoring must occur at multiple scales: micro (e.g., microhabitat requirements); landscape (e.g., regional ecosystem function, population range, watershed); and global (e.g., meteorological conditions, global warming). Given the enormous resources necessary to characterize and track species and ecosystem function at several scales, there is a strong underlying need to coordinate, collaborate, and consolidate the habitat and species data gathered from these multiple scales.

Key Issues and Current Science

Across the country, large volumes of data are collected at varying scales for highly diverse applications by many groups and individuals. Sometimes data are collected without clearly identifying the objectives or verifying data standards. Further, for a variety of reasons, some data may never be analyzed. In other regions and locales, little research has been conducted so there is a paucity of data (e.g., Pacific ecosystems used by the Navy/Marines).

[16] Aerial LIDAR provides this quality of data but is cost-prohibitive for most project applications.

Current scientific capabilities include automated data collection, remote sensing, storage, and analytical/summary tools, many of which are being developed in GIS/data management platforms. Thermal infrared, radio telemetry, LIDAR, and other inventory and monitoring techniques are being applied in the field; however, their application can be cost prohibitive for site-specific projects at military installations. At a national level, efforts are underway to create databases that compile and manage TER-S and ecosystem data (e.g., NatureServe, DoD Document and Data Repository), but greater information sharing is still needed.[17]

Current Needs and Gaps

Significant resources are required to collect and track ecosystem data at multiple scales. Needs and gaps range from basic species information to adequate technology. Specific needs identified include:

- More information on TER-S taxonomy, life history, and geographic distribution
- More information on the biodiversity and biological history of listed species and ecosystems; within the Pacific region, most notably Hawaii
- Cost-effective and automated systems to collect and compile data.

Future Direction

In the future, multiscale monitoring will need to focus on developing cost-effective monitoring networks for both species and habitats. Specific approaches to address future needs are highlighted under Section 5.1.1, *Monitoring Technologies*, *Future Direction*.

5.1.3 Protocols, Guidelines, Metrics, and Indicators

Having meaningful data on species and habitats of interest is important for effective planning, policy, and management. To that end, relevant monitoring protocols and guidelines have been developed to compile meaningful data for decision makers. Ideally, these protocols should be developed using rigorous scientific methods to ensure that the metrics measured in the field produce meaningful data for trend analyses, and for addressing critical decisions related to the long-term recovery and sustainability of listed species.

Although the scientific method can be used to develop accurate, relevant, and comprehensive protocols for listed species, many agencies lack the resources to implement them. Given the lack of resources available for TER-S monitoring, it is important that data collection focus on those key metrics that are readily measurable, relevant, and biologically important. Indicators can be developed to measure critical components of an ecological system using cost-effective methods, including remote sensing and automation tools. As such, indicators can serve as an early warning sign to track the condition of an ecosystem, habitat, or population.

[17] www.natureserve.org; www.mynbii.gov

Key Issues and Current Science

Protocols often are developed without using rigorous scientific methods and research, and without undergoing sufficient peer review. As a result, many protocols include standards for collecting various metrics that have no relevancy to the long-term recovery and sustainability of a listed species. Complicating the problem, there is often limited data on the basic biology of listed species on which to develop monitoring protocols. Without this knowledge, even elaborate and expensive monitoring protocols may not yield meaningful management data. Another concern is that monitoring methods tend to change over time due to factors such as an improved biological understanding, changes in funding, changes in personnel, changes in priority, and changes in the questions being addressed. Consequently, monitoring trends cannot be accurately assessed.

Further, the allocation of monitoring resources across species and ecosystems must be addressed. Beyond the charismatic TER-S, many species have not yet been surveyed, let alone monitored using a rigorous peer-reviewed protocol. Additionally, there is a need to focus monitoring resources on evaluating and tracking "endangered ecosystems," as opposed to the TER-S that live in those systems. Though limited guidance or protocols exist for tracking "endangered ecosystems," using such an approach can benefit both the TER-S and the other species that share "endangered ecosystems" habitats.

Current scientific capabilities include rigorous statistical theory and methods for developing protocols. Overall, the theory and statistics of monitoring are generally well understood and accepted. However, the methods for species-specific monitoring that can address management questions significantly impacting survivability (e.g., microhabitat requirements, specific stressors, critical life-cycle timing, nest predation) generally are not available. In many cases, guidance exists, but the approach may not produce data that are meaningful for addressing key management questions. On occasion, pilot-scale monitoring protocols are developed for key species that address critical management questions using a rigorous scientific review process. These protocols include feedback loops for management/decision making. In addition, the NPS and USGS are developing an inferential monitoring approach (versus a traditional index-based method) for species-specific protocols.

Current Needs and Gaps

The need for standardized, peer reviewed, and validated monitoring protocols was identified as a high priority. Other needs and gaps ranged from species-specific protocols that assess population-level impacts to relevant indicators for highly illusive species that cannot be monitored at the population level. Specific needs identified include:

- Developing comparable and compatible monitoring protocols for target species and habitats through a collaborative process with regulators, managers, operators, and biologists

- Better understanding of species biology and requirements in support of designing effective monitoring protocols (e.g., key microhabitat needs, climatic/environment issues, and stressor issues that impact population dynamics)

- Assessing how population genetic information is captured and recorded (as input for Population Viability Analyses)

- Developing a mechanism to identify ongoing TER-S monitoring and conservation efforts to facilitate communication and collaboration among efforts at multiple scales

- Assessing the use of genetics to determine the "value" of various populations for the long-term viability and recovery of the species, which would lead to the identification of populations that are most in need of protection

- Characterizing distinct population segments (DPS) based on genetics

- Developing reliable approaches for monitoring very rare or illusive species

- Developing monitoring methods that provide results in less than one year

- Developing simple and inexpensive monitoring protocols that can determine species presence/absence

- Assessing the impact of invasive species on ecosystem processes. There is a need to develop thresholds for TER-S survivability based on the interactions between invasive and imperiled species,, as well as for indicators of species/ecosystem integrity

- Developing metrics for tracking and assessing ecosystem health and landscape-scale change

- Conducting targeted peer-reviewed scientific studies (life history, population, stressors) on listed species that impact the military mission. Using these studies, develop species-specific monitoring protocols that address specific and relevant management questions. Protocols should be peer reviewed and should, as appropriate, address the probability of false negatives when monitoring (i.e., statistical reliability that an area is clear of TER-S).

Future Direction

To best address needs in this arena, scientists must develop standardized and rigorous protocols and guidelines that will yield meaningful data for decision makers. Specific approaches to address future needs include:

- Promote the use of peer reviewed monitoring protocols that explain how data are to be collected, managed, analyzed and reported, and are a key component of quality assurance for resource monitoring programs.

- Develop indicators and metrics, as part of monitoring protocols, that can be readily measured (e.g., with Internet-based or remote system networks), analyzed using decision support systems, and validated against key biological parameters for cost-effectiveness. Key indicator species (birds, insects, others) and/or other metrics can be identified to track trends in ecosystem health, management impacts, and restoration initiatives.

- Develop an accessible and searchable database of monitoring activities, protocols, and resource assessment methodologies available for use by resource managers and scientists,, as well as policy and decision makers.

5.2 HABITAT MANAGEMENT AND ASSESSMENT

Appropriate habitat management is essential for the conservation and management of TER-S, but assessing management needs appropriately requires sophisticated tools and technologies, as well as sufficient resources to utilize them. While intensive studies must necessarily be conducted at the local scale, the consideration of progressively larger scales of references is becoming more prevalent. For DoD, this means furthering its knowledge of TER-S and associated habitat off the installation, thus managing on an ecosystem-wide or regional basis. Doing so is critical for increasing management options and for supporting range-wide recovery.

5.2.1 Modeling and Other Assessment Tools

Although statistical methods and theoretical approaches have been used for decades, the more recent generations of models have grown in sophistication and relevancy. Further, GIS and remote sensing applications have become a vital component in developing illustrative landscape-scale simulation models, facilitating an understanding of various management issues. TER-S biological health, population status, habitat conditions, and other attributes all have been modeled using both empirical and theoretical models.

Key Issues and Current Science

Habitat models often have been viewed as tools for better understanding complex systems, though not for making specific and defensible management decisions. Current scientific capabilities include the development of biophysical models, GIS-based landscape models, and statistical ecosystem models. Biophysical models applied at a landscape scale have been used to assess the impact of land management decisions on target species and to identify sensitive time periods/conditions that may stress species. GIS-based landscape models have been developed to identify potentially viable TER-S habitat for future restoration and for targeting areas for monitoring. In addition, statistical ecosystem models have been developed to estimate the effect of management decisions on target species at a landscape scale.

Current Needs and Gaps

Biophysical, GIS, ecosystem, and landscape-scale models all can be used to assess the long-term impact of alternative management regimes on listed species and the habitats that support them. Theoretical and empirical models need to address practical issues that are important to TER-S conservation and management. For example, GIS-based landscape models need to be capable of

accurately evaluating "what if" scenarios (e.g., predicting landscape-scale changes based on a given suite of management regimes).

Needs and gaps focus on the enhancement of biophysical and landscape-scale modeling approaches. Specific needs identified include:

- Enhancing and validating biophysical models to assess population dynamics and habitat structure and address species-specific management issues. Once refined, user interfaces for prototype models need to be enhanced for wider application and distribution.

- Developing defensible landscape-scale models for making management decisions. Such models are particularly needed to predict installation susceptibility to invasive species.

Future Direction

In the future, habitat modeling must focus on developing more sophisticated landscape-scale and biophysical models to provide meaningful data to decision makers. Specific approaches to address future needs include:

- Develop ecological/population forecasting models that incorporate life history, status, trends, and the effects of management decisions. These models should be peer reviewed, defensible, transparent, and structured to support management decisions.

- Develop DoD-wide risk assessment and decision support tools for establishing buffer parameters and design.

5.2.2 Habitat Management for TER-S

Habitat management can occur at varying scales, from the microhabitat needs of an individual species to long-term landscape manipulation for a region. An important theme reiterated was the need to focus on the management of habitat rather than the biological needs of a single species. It is at the landscape scale, when trying to formulate and prioritize habitat management goals and objectives that address a large suite of issues, that potential conflicts and solutions can be addressed.

Key Issues and Current Science

Too much focus is currently placed on protecting individual species rather than conserving and protecting the "endangered ecosystems" that support those species. By conserving and managing important habitats, not only TER-S but non-listed species that use the same habitats can be protected. Although there are laws protecting certain habitat types (e.g., wetlands), other habitats (e.g., fragmented uplands requiring specific fire regimes) remain unprotected. Compounding this, TER-S projects often are regulatory driven and require a focus on species-specific issues. The result is a significant loss of ecosystem coverage and decline of ecosystem integrity. Thus, a balance is needed between species-specific regulatory actions and broader ecosystem management and restoration objectives.

For these same regulatory reasons, management procedures are not as well documented or developed for many ecosystems as they are for some listed species. In addition, management and monitoring of TER-S within certain ecosystems (e.g., karst, playas) can present unique challenges that require different approaches. Current scientific capabilities include the development of habitat indicators and management prescriptions. For example, efforts are underway to identify indicator species using various screening methods in order to track habitat quality and management effects.

The NPS currently is compiling a database of management prescriptions used on its land for TER-S species and habitat. NatureServe also is developing comprehensive management prescriptions for ecosystems and compiling them into an online database.

Current Needs and Gaps

Significant resources are necessary to manage habitat for the protection of listed species. Needs and gaps range from ecosystem-based management prescriptions to restoration of ecosystems following invasive species disturbance. Specific needs identified include:

- Using ecosystem-based management approaches rather than focusing solely on species-specific approaches. Landscape-scale habitat management plans represent a potential forum for addressing trade-offs between species and ecosystem conservation and restoration. The Natural Community Conservation Planning (NCCP) approach used in California may be a good model for balancing ecosystem and species-specific conservation goals and objectives.

- Obtaining additional genetic, population, and habitat requirement data for many TER-S.

- Developing effective plans, guidelines, approaches, and technologies for ecosystem restoration following implementation of invasive species control measures. Unless such measures are taken, invasive species can readily become reestablished. The availability of native species following control of invasive species is a key concern.

Future Direction

To inform habitat management, research must focus on developing more sophisticated landscape-scale management approaches that can provide meaningful data to decision makers. Specific approaches to address future needs include:

- Develop a peer-reviewed process for collectively managing, conserving, and restoring ecosystems and listed species through stakeholder collaboration.

- Conduct TER-S risk assessments from a genetic perspective to help elucidate issues related to population isolation and habitat fragmentation.

- Consolidate, coordinate, and codevelop ecosystem-based and species-specific metric data management systems and tools for habitat management within a given region.

5.3 PLANNING AND MITIGATION

Comprehensive and proactive planning and mitigation measures are necessary to support the long-term recovery of TER-S on DoD and adjacent lands while fulfilling the military mission. However, all too often, the policies and regulations that provide funding vehicles for natural resources management initiatives are species- or habitat-specific and unable to address the broad range of issues relevant to TER-S. A need to broaden the framework for managing TER-S to include proactive conservation is apparent. Further, due to the limited availability of funds, resources must be allocated judiciously. Leveraging resources among partners with common issues can serve to benefit all participants.

5.3.1 Framework

Having a well-defined framework for TER-S conservation and management on DoD and adjacent lands is an important component of an overall approach based on existing policy, regulations, and resources. These three factors, and the best available science on which they depend, have a significant impact on the conservation and management of TER-S on DoD and adjacent lands, and provide a valuable foundation for decisions regarding resource allocation. Unless policies, regulations, and resources begin to address and enable proactive conservation initiatives, they may be of limited use in preventing additional endangerments that may ultimately further restrict mission capabilities.

Key Issues and Current Science

In recent years, the approach to TER-S conservation and management has shown some shift from a species-specific to an ecosystem-based emphasis. This shift is reflected broadly in the general literature and in various guidelines and instructions for natural resource management personnel across the military services. Numerous initiatives, such as the SERDP Ecosystem Management Project (SEMP), have been initiated to investigate and monitor ecosystem structure, function, and integrity. Nevertheless, current management emphasis remains somewhere between species-specific and ecosystem-based. This is true even though the potential role for and benefits of proactive conservation on a broad scale have increased significantly.

Engaging in effective proactive conservation efforts can prevent species listing and promote listed species recovery. Conserving species before they are listed increases management flexibility (i.e., requires less regulatory oversight), while recovering species can potentially increase options for land use on DoD installations.

Current Needs and Gaps

TER-S projects often are regulatory driven and thus require a focus on species-specific issues. Yet, as has been discussed, there is a need to focus management efforts at the ecosystem scale, rather than on the biological needs of any single species. To augment existing policy, regulations and resources, managers need an effective framework for TER-S conservation efforts and increased flexibility in implementing proactive conservation measures. The framework and the

policies that support this approach must provide the necessary tools to assess impacts and support management decisions in the field. Specific needs identified include:

- Increasing efforts to manage at-risk species and ecosystems on DoD installations.
- Investigating long-term management approaches as a precursor to species delisting on all DoD installations with recovery goals.
- Measuring the benefits and limitations of different approaches from both a species impact perspective (i.e., physiological, behavioral, and reproductive impacts) and a regulatory acceptance perspective.
- Developing decision support tools for management actions related to TER-S and their habitats.
- Developing models that forecast mission constraints from TER-S and invasive species and demonstrate cost avoidance realized by proactive conservation initiatives.
- Conducting a cost/benefit analysis for species-at-risk and invasive species similar to that undertaken for pollution prevention initiatives, where the metric is loss of training lands. This would apply especially if conservation and management actions are undertaken prior to a species listing or invasive species introduction, since significant long-term cost savings and reduced impacts to the military mission and species could be realized.
- Based on results of the cost/benefit analysis, increasing support and funds for Early Detection and Rapid Response systems for invasive species.

Future Direction

To be successful, any future TER-S conservation and management framework must focus on proactive conservation to promote regional and range-wide recovery of listed species. Similarly, future policy and regulatory actions should focus on providing legislative support for proactive conservation efforts and allowing for the development of new approaches to risk assessment. Specific approaches to address future needs include:

- Create incentive-based policies to support proactive conservation for species-specific and ecosystem-wide issues
- Develop policy to address public review of science related to TER-S issues
- Investigate ecological risk assessment as a potential tool for regulatory consultation
- Gain increased knowledge of TER-S off the installation (encompassing full range), thereby improving on-installation management options

- Establish partnerships among regional stakeholders to achieve common range-wide recovery goals.

5.3.2 Resource Allocation

Beyond the impact of policy and legislation on funds for the conservation and management of TER-S on DoD and adjacent lands, there is ultimately a limited amount of funds available for natural resource initiatives. Resources must be allocated efficiently and leveraged heavily to maximize benefits to all involved stakeholders.

Key Issues and Current Science

Limited agency resources for TER-S conservation and management are a pervasive issue. Low funding levels impact the number of natural resource management staff in the field, as well as their ability to collect, manage, track, and analyze data relevant to the conservation and management of TER-S and their habitats. A strong indicator of this lack of resources is the incomplete status of many USFWS recovery plans, placing those being regulated by the agency in the difficult position of accepting and implementing unspecified management actions to support recovery of a given species within a specified time frame.

Most available resources are currently directed toward high profile (i.e., "charismatic") species that may be in less peril than other species, or may actually be stable or recovering. Agencies are beginning to recognize the need to reevaluate current resource allocations to focus on those species that are most imperiled and/or can benefit most from dedicated funds. Since many species occupy habitat across geopolitical boundaries or are of other mutual interest to diverse stakeholders, it is important to leverage resources among agencies as efficiently as possible. For example, DoD recently became a full member of the National Interagency Fire Center (NIFC), which allows it to work collaboratively with partners on fire-related initiatives and to pursue funding for fire-related research opportunities.

Current Needs and Gaps

Given limited funds, it is critical that resources be allocated in such a way that their expenditures result in the greatest possible positive impacts to TER-S and their habitats. Specific needs identified include:

- Developing prioritization criteria that are integrated with the Buffer Lands and Range Initiative

- Prioritizing resources to address invasive species based on threats to sensitive resources and training/operations, as well as their invasiveness (i.e., spread potential)

- Providing resources *after* control of invasive species has been achieved to promote effective habitat restoration

- Providing consistent multiyear funding to support longer-term research and sustained monitoring initiatives

- Shifting resource allocation from charismatic to other species, especially those considered "low-hanging fruit," that have the potential for near-term impacts

- Completing the necessary evaluations to de-list species, and using these tangible successes to impact future funding levels for TER-S conservation and management

- Reallocating funds to achieve more results by focusing recovery efforts on plants and invertebrates, which cost less

- Increasing DoD presence at the RIFA conference, as well as communication with the Armed Forces Pest Management Board, given that fire ant management and control relevant to TER-S impacts appears to be a DoD-unique need.

Future Direction

Properly framing the issues to be addressed, leveraging resources among stakeholders with shared interests, and prioritizing needs in a more holistic context were all highlighted as future directions for resource allocation. Specific approaches to address future needs include:

- Explore questions related to TER-S plants that can be addressed more broadly (i.e., not species-specific)

- Review TER-S, their habitats and requirements, and determine which agencies are best suited to contribute to their recovery.

5.4 MILITARY IMPACTS AND ACTIONS

DoD manages significant numbers of TER-S on lands designated for soldier training and weapons testing. Often, areas used by wildlife must be maintained for long-term sustainability to ensure that soldiers, sailors, airmen, and marines can train as they fight and continue to test weapons systems under realistic conditions. Over the past decade, it has become clear that 1) habitat supports the military mission, 2) disturbance may enhance biodiversity, and 3) DoD cannot research or manage species in isolation.

5.4.1 Military-Unique Stressors

DoD's mission-critical training and equipment requirements include running armored tracked vehicles over varied terrain, using smokes and obscurants in different environments, and firing or dropping live munitions. To meet these and other training and testing needs requires large expanses of land, sea, and airspace. Beyond the basic issue of availability, constraints on DoD installations include critical habitat for TER-S, jurisdictional wetlands, boundary development pressures, and other forms of encroachment. The result is that less and less area is available to support an ever-expanding mission requirement.

For example, although Fort Hood has been tasked to support nine military brigades, the available land can support less than one to doctrinal standards. The Army can and does still train all troops stationed there, but it must do so using an altered training regime. Thus, any restriction of land use can and does have a significant impact. In the past, requirements to avoid areas inhabited by the GCW and BCV have exacerbated these access restrictions. Yet, through focused research and management efforts, restrictions due to the presence of GCWs and BCVs have largely been mitigated or eliminated. At many other installations, however, management of TER-S continues to negatively impact training (e.g., Naval Base Coronado, California).

Key Issues and Current Science

As good stewards of the environment, DoD continually assesses the impacts of current and future training actions on listed species and endangered ecosystems. As the military mission and requirements change, future impacts (including the expanded use of training lands and the development of new ranges) need to be monitored and assessed. In addition, as the military continues to enhance habitat within its boundaries, it is faced with the distinct possibility that its excellent stewardship could actually *increase* restrictions on future training. This situation becomes increasingly likely as rare species thrive on installations while surrounding off-installation habitat continues to degrade or be developed. Using the past as a predictor, it seems likely that there will be increased species listings where the best remaining habitat occurs on DoD lands.

To date, significant levels of resources have been allocated to assess the impacts of military training on key threatened and endangered species (e.g., RCW, gopher tortoise, Indiana bat). Impacts studied include noise and chemical compounds associated with DoD-unique equipment such as munitions, smoke and obscurants, and other pyrotechnics. In some cases, sophisticated bioacoustical (e.g., EcoEars) and other equipment have been developed to monitor TER-S trends relative to military actions. Intensive conservation efforts and, sometimes, disturbance from military training have been shown to significantly benefit some of these listed species.

Current Needs and Gaps

While impact assessments represent a critical component of consultation with the USFWS, the lack of basic species information is problematic. TER-S conservation and management on DoD and adjacent lands requires an awareness of the impacts that the military mission is having on species and habitat, as well as the impacts that TER-S and habitat are having on the fulfillment of testing and training requirements. Specific needs identified include:

- Quantifying the number of acres impacted by TER-S and their effects on military mission capabilities

- Improving understanding of how military training and disturbance affect TER-S populations (both positively and negatively)

- Requiring that analyses of military training and disturbance effects on TER-S populations be peer reviewed

- Better understanding of the impact that management actions for particular TER-S (e.g., prescribed burning for RCWs) have on non-target TER-S and their habitats
- Investigating quarantine and cleaning procedures for transportable materials (e.g., military vehicles) to prevent spread of invasive species throughout the continental United States
- Exploring physiological measures of stress
- Studying the effects of vibration noise on hibernacula or maternity colonies for bats
- Investigating the effects of barriers on TES populations in small streams
- Assessing the potential impacts of night training on TER-S
- Reviewing migratory bird species of concern to determine if DoD actions may have a significant impact on their populations.

Future Direction

The recommended future direction for military-unique stressors focuses on practical assessments of military impacts, responsibilities, and restrictions. Specific approaches to address future needs include:

- Conduct a comprehensive evaluation of all habitats represented on military property, compare to habitat remaining on lands under other ownership, and assess the burden that DoD can realistically be expected to bear for TER-S conservation and management.
- Develop a method, directive, or policy to ensure that if TES populations are self-sustaining at an installation, operational requirements to test and train will not be unduly compromised. Monitoring would continue.

5.4.2 Species-Specific Impacts and Protection

To comply with the ESA, DoD expends considerable effort to closely monitor species-specific impacts on its lands and to ensure that listed species are protected from various stressors.

Key Issues and Current Science

Current studies suggest that habitat degradation, and not military training, is having a significant impact on listed species. In fact, one study indicates that military training actually creates microhabitat diversity needed by certain listed species.[18] TER-S impacts are assessed in light of

[18] Warren, S., R. Buttner, D. Dale, N. Whelan, S. Holbrook. 2005. Biodiversity of Threatened and Endangered Species on Army Training Lands. TER-S Conference Presentation, June 7, 2005. Center for Environmental Management of Military Lands, Colorado State University, Fort Collins, CO.

an ever-changing environment due to urban encroachment, variable weather conditions, spreading invasive species, regional habitat loss, and changes in the military mission. Over time, as habitat off installations is adversely impacted by urban sprawl and other stressors, protected habitat on DoD lands has and is continuing to become increasingly critical to the long-term survival of listed species.

Enhanced protection of species also becomes important as remaining populations become more vulnerable to single-event stressors, including climatic changes, introduction of invasive species, nest predation, and more. Thus, long-term survival of protected populations requires management plans that look beyond the fenced boundary and applying methods for closely monitoring and protecting fragile populations from isolated catastrophic events (e.g., hurricane, nest predation).

Current scientific capabilities include multiscale assessments of species-specific stressor impacts on listed species using radio telemetry, bioacoustics, remote sensing, genetic monitoring, and biophysical models. Both genetic monitoring and biophysical models have been used to identify species-specific stressors and to improve habitat conditions for listed species.

Current Needs and Gaps

Numerous stressors that impact listed species are not well understood. These data gaps make it difficult to design effective monitoring programs, identify important metrics and indicator variables, and mitigate species impacts and stressors. Specific needs identified include:

- Identifying biological and habitat requirement data for many listed species.
- Collecting additional data on the impacts of nest predation for many TER-S, since nest predation (from natural predators and invasive species) can quickly destroy years of expensive habitat and species protection efforts.
- Developing nest protection and monitoring technology utilizing Internet-based monitoring sensors and innovative protection devices, if and when warranted.
- Developing, demonstrating, and validating barrier technologies for feral animal movement.
- Developing improved models that synthesize complex life histories, physiology, and behaviors at the population level. For example, how do incremental changes in survival affect population recovery? How will climate change alter population dynamics?
- Exploring opportunities to apply data collection tools and models developed for salmon to other species, such as TES desert fishes, Colorado River fish, and delta smelt, as well as bull trout, snails, or invasive plants that impact TES.

- Assessing the presence and impact of upper respiratory tract disease (URTD) in the gopher tortoise, and identifying potential replacements or means to augment ELISA.[19]
- When controlling RIFA, considering habitat between caves and near cave entrances (based on the foraging area of species that provide nutrients for TER-S).

- At Naval Base Coronado in California: 1) studying the current inexplicable cause of very sick and dying adult plovers, 2) investigating how to discourage terns from nesting, and 3) assessing the success and establishment of captive rearing programs.

Future Direction

The recommended future direction of species-specific research ranges from integrating the military mission with research objectives to assessing the biological and environmental needs of listed species. Specific approaches to address future needs include:

- Better integrate management/military needs into research objectives and study design.

- Develop more effective management tools for addressing encroachment.

- Conduct TER-S research on habitat needs, genetics, life history, and population dynamics.

- Develop cost-effective species monitoring methods to address specific management issues.

- Assess opportunities for conservation conveyance through Base Realignment and Closure (BRAC).

5.5 TECHNOLOGY TRANSFER AND OUTREACH

The integration and dissemination of technology and information related to TER-S is an important aspect of cost-effective ecosystem management. Developing effective methods for sustaining the DoD training and testing mission, while simultaneously protecting threatened and endangered species, is a challenge that can only be addressed through strong partnerships. Establishing and fostering such partnerships was one of the main objectives of this symposium.

5.5.1 Formation of Partnerships

Through partnerships, TER-S conservation and management efforts can be integrated across agencies, ecosystems, and species. Such partnerships facilitate leveraging resources and knowledge and minimize duplication of effort. In addition, it is important to identify additional stakeholders that can and should be targeted for outreach and education. By reaching out to relevant groups and individuals, negative attitudes can be modified, the potential for future conflict can be reduced, and mutually desirable TER-S related objectives can better be achieved.

[19] For a discussion of ELISA (Enzyme-Linked Immunosorbent Assay), see http://www.biology.arizona.edu/immunology/activities/elisa/main.html.

Key Issues and Current Science

Many partnerships already exist among agencies actively engaged in TER-S conservation and management on DoD and adjacent lands. Nevertheless, there are numerous opportunities to realize greater benefits by strengthening existing partnerships (perhaps through increased collaboration), expanding to include new stakeholders, and disseminating information to the public about the challenges being faced and successes being accomplished.

The targeted Community of Practice identified for technology transfer efforts includes:

- Policy makers and managers
- Technical community actively involved in monitoring
- Researchers
- Information transfer exchange community/sponsors.

Current Needs and Gaps

The formation, maintenance, and strengthening of partnerships requires an awareness of past successes and failures, current strengths and weaknesses, and future challenges and opportunities. Such holistic assessments support strong collaboration. Specific needs identified include:

- Identifying existing collaborations and their lessons learned
- Undertaking systematic species-by-species investigation of past successes
- Highlighting what DoD is doing well (e.g., landscape-level change, model installation)
- Establishing networks of technical experts to be consulted as necessary
- Incorporating DoD-related goals into the USGS five-year planning program
- Hosting regional meetings to assess partnership opportunities among stakeholders
- Leveraging and strategically planning landscape habitat management and monitoring programs across government agencies, NGOs, private institutions, and communities
- Assessing status and limitations of models that predict susceptibility to invasive species (e.g., GARP) and, where necessary, augmenting and validating them for DoD application
- Educating industry of desired modifications for the next-generation of tagging technologies and data requirements to meet TER-S research and management needs.

Future Direction

For TER-S conservation and management partnerships to be successful, they must focus on improving collaboration among existing and new partners, as well as on engaging the public. Specific approaches to address future needs include:

- Organize and implement system to provide cross-training of leadership, as appropriate, on other agencies' missions.

- Develop processes for integrating, collaborating, sharing, and leveraging monitoring initiatives at various scales among agencies, research institutions, and the public.
- For relevant species (e.g., BCV, GCW), compile significant amounts of scientific information amassed by researchers, and relay this data to natural resource managers via predefined avenues (e.g., onsite meetings, workshops, synopses).

- Recognize the essential role of science communication for management applications.

5.5.2 Communication Among Partners

Several of the technical sessions stressed the need to focus TER-S conservation efforts on "endangered ecosystems" as opposed to individual species. Monitoring and managing habitat, as well as individual TER-S, requires significant resources. Given individual agency and organization fiscal and other resource constraints, it makes sense to leverage habitat and TER-S research and management initiatives within a defined geographical area, thereby achieving a more comprehensive assessment of ecosystem health, trends, and management approaches.

Key Issues and Current Science

Generally, there is no common forum for collaborating and sharing data based on research within a given ecosystem. Professional venues for technology transfer tend to be organized by isolated technical areas of interest or by species/taxa, rather than focused on a common geographical area or series of management objectives. Furthermore, many TER-S research, monitoring, and conservation initiatives are done in isolation, even within the same geographical area. Since these studies often use similar baseline data, some duplication of effort occurs in describing and tracking ecosystem condition and health. This inefficiency limits the amount of new monitoring that can be done, given the fixed availability of resources.

Current scientific capabilities include regional and national forums for exchanging some elements of ecosystem data and research. For example, several web-based portals for information exchange and collaboration have been developed (e.g., National Biological Information Infrastructure [NBII], NatureServe, Defense Environmental Information Exchange [DENIX], Phoenix). In addition, there are customized web-based software solutions focused on collaboration and community building for achieving common goals across diverse organizations and groups (e.g., I-INFO, developed by APEX Innovations).

Current Needs and Gaps

Access to timely and accurate scientific information is critical to TER-S conservation and management. Given the expense and time needed to collect significant amounts of data, it seems wise to leverage scarce resources (e.g., labor, funding) to meet common goals, such as filling baseline data gaps and addressing basic research questions. Specific needs identified include:

- Centralizing demographic data to support predictive tools for the impacts of management actions on habitat and species distribution
- Cost-effectively managing long-term monitoring data as it supports regional biological assessments and consultation
- Increasing professional collaboration on a wide range of topics (e.g., sharing baseline data sets, conducting more joint studies)
- Consolidating existing landscape-level data among relevant organizations and projects
- Sharing cost of using expensive technologies and data sets (e.g., LIDAR)
- Developing sampling protocols that ensure synthesis of datasets, especially for trends analysis
- Enhancing Web-based portals to allow for exchange, collaboration, and leveraging of TER-S initiatives for defined geographical areas (e.g., ecosystem) and/or shared objectives. Such a system could be built on an existing gateway or portal (e.g., NatureServe, NBII). Information types to be included in the Web-based system include:
    - Taxa
    - Distribution
    - Life history
    - Lessons learned
    - Case studies
    - Regulatory compliance documents
    - Expertise
    - Protocols
    - Technology standards
- Establishing an interactive database with GIS capabilities for invasive species; identifying existing databases (e.g., National Council of Invasive Species, Forest Health Management, Natural Resources Conservation Service, TNC); assessing and identifying gaps related to DoD; consolidating information; and increasing accessibility of that information among the DoD community
- Developing more effective public outreach materials to share news that DoD is a good steward of its resources.

Future Direction

The future of technology transfer appears to be centered around Web-enabled database technology that regional stakeholders with shared interest in taxa, technology and protocols, management goals and objectives, and/or regulators can use. Specific approaches to address future needs include:

- Implement a comprehensive Web-based information exchange conduit for collaboration among partners (i.e., continue to improve and expand current data sharing efforts).

- Continue and expand interagency collaborative efforts (e.g., Science Forum).

6.0 SUMMARY OF RECOMMENDATIONS

This section highlights the overarching themes and issues that pervaded the TER-S Symposium and Workshop. Information captured during the symposium plenary and technical sessions, panel discussions, and workshop breakout groups and discussions form the basis for these recommendations. Specifically, recommendations were identified through an analysis of the key issues, needs, and future directions identified for each TER-S technical area discussed in one or more of the technical sessions and evaluated at the workshop (i.e., TER-S monitoring, habitat management, mitigation, military impacts, and technology transfer), as detailed in Section 5. From these top-level recommendations, specific research queries may be formulated and projects funded.

6.1 LIFE HISTORY RESEARCH

There is a serious lack of basic biological information (life history, population dynamics, stressor impacts, biological needs, genetics) for many listed and at-risk species, particularly plants. Without this knowledge, even elaborate and expensive monitoring protocols may not yield meaningful data for managing species. Only through a clear understanding of the species and the stressors that directly impact health and population viability can suitable protocols and management approaches be developed to conserve listed and at-risk species (see Sections 5.1.3 and 5.4.2 for further information). The lack of basic biological information also complicates the assessment of DoD impacts. It was further recommended that such research be conducted through rigorous scientific and peer-reviewed methods to ensure the adequacy of findings.

6.2 PROACTIVE CONSERVATION EFFORTS

Typically, a significant portion of the available conservation resources are allocated to the more charismatic of the federally-listed species. When considering the threat of invasive species and the host of species that may be listed in the near future, it is evident that additional resources should be focused on proactive conservation measures in order to prevent additional species listings. This should include funds for the control of stressors (such as invasive species) before serious problems arise (see Section 5.3.3 for further information). Research that evaluates the cost-benefits associated with proactive conservation efforts (as opposed to reactionary

approaches) could help foster new policies and funding to prevent new listings, and save resources in the long-term (see Section 5.3.2 for further information).

6.3 MONITORING PROTOCOLS

In many instances, monitoring protocols, guidelines, and indicators are not developed for TER-S while, in other cases, protocols exist but do not provide meaningful data for decision makers. This is because many protocols are developed without the use of a rigorous scientific approach and may lack sufficient peer review. Furthermore, the evolution in protocols over time makes trend analysis impossible. It is thus imperative that comparable and compatible protocols be developed for key listed species. These protocols should include guidelines for monitoring and indicators, as appropriate, to ensure efficient and consistent collection of meaningful biological data. Protocols should be developed through a rigorous scientific approach and peer review process that incorporates how data are to be collected, managed, analyzed, and reported to ensure efficient collection of key data elements directly relevant to key management decisions (see Section 5.1.3 for further information).

6.4 PREDICTIVE MODELS

To manage and conserve TER-S habitat at a regional scale, the land manager must apply a complex suite of management measures across a wide landscape in coordination with other regional land holders to achieve ecosystem goals. In many cases, the results of these management decisions may not be seen for decades (e.g., restoration of long-leaf pine habitat). To assist in such efforts, GIS-based landscape-scale ecosystem models can be useful tools for predicting the long-term implications of various management decisions. To that end, pilot studies and research projects have been executed to build such models, but more research effort is needed to refine, validate, and expand these predictive modeling efforts (see Section 5.2.1 for further information).

6.5 CONSERVATION AT A REGIONAL SCALE

There is a need to focus TER-S conservation efforts on the protection of "endangered ecosystems" at a regional scale, rather than managing the biological needs of individual species (see Sections 5.1.1, 5.2.2, and 5.3.1 for further information). By protecting the habitat and range needs of any listed species (rather than focusing on the species itself), land managers can ensure the long-term sustainability of the listed species, as well as all other species that depend on the same habitat. It was recommended that research efforts focus on developing more sophisticated regional management tools and approaches, including predictive models (see Section 5.2.1), genetic population assessment (see Section 5.2.2), and habitat monitoring technology using remote sensing and automated collection/analysis tools *(*see Sections 5.1.1 and 5.1.2).

6.6 TECHNOLOGY TRANSFER

Funds available for monitoring and conserving listed species are inadequate. No one organization has sufficient resources to collect the necessary data, much less put into place the conservation and restoration measures needed to curb the loss of habitat that is occurring at a continental scale. Leveraging conservation-related information and actions across agencies and in partnership with private initiatives within defined ecological regions offers a solution to this

problem (see Section 5.5.1 for further information). Application of modern communication technology (e.g., Web-based collaboration software tools, such as those developed by I-INFO) and other existing Web-based portals (e.g., NBII, NatureServe, DENIX, Phoenix, GCPEP) can be used to share monitoring data, lessons learned, and research and technology information. In addition, by working together, partners can leverage knowledge and resources by codeveloping ecosystem-based projects.[20] Through the development and application of new technologies and execution of pilot projects based on significant collaboration, it may be possible for TER-S conservation organizations and partners to yield significantly enhanced results. To that end, it was recommended that Web-based collaboration tools, portals, and other methods be developed and integrated into future research efforts (see Section 5.5.2 for further information).

7.0 CONCLUSION

With the continued loss of valuable TER-S habitat, the threat to TER-S and, with it, the threat to continuing and expanding DoD's testing and training mission will continue to grow. Despite the efforts of natural resource management staff to protect and enhance TER-S habitat on DoD lands, DoD will continue to face tough TER-S compliance issues because of stressors beyond the installation boundary and, often, beyond its control. To effectively address these issues, TER-S issues must be addressed proactively, in partnership, and at a regional scale.

Given the limited resources available to address such significant problems as continental habitat loss, it is imperative that future R&D efforts focus on building cost-effective and automated systems for monitoring, tracking, and executing management decisions. R&D needs must focus on providing managers the tools they need without increasing their resource requirements. Technology applications that collaborate to leverage limited resources across agencies, NGOs, and private institutions will significantly enhance future TER-S conservation efforts.

Furthermore, R&D must provide land managers with tools to predict the likely long-term outcomes of various management decisions across a regional landscape scale, thereby helping ensure that resources allocated today will bring beneficial results decades into the future. By taking the necessary proactive steps, DoD will be able to sustain and enhance its military training and testing capabilities, while simultaneously playing a vital role in conserving listed and at-risk species and their habitats for generations to come.

[20] For example, the DoD Legacy Resource Management Program has funded a number of ecosystem-based partnership efforts, including the Gulf Coastal Plain Ecosystem Partnership, the Southwest Strategy, and the Grand Bay-Banks Lake Stewardship Partnership. See www.dodlegacy.org for additional relevant projects.

APPENDIX A:
Symposium Agenda

Tuesday, June 7			
Registration/Information Desk (0700-1630)			
Continental Breakfast (0800-0830)			
Plenary 1	Mr. Bradley Smith SERDP		0830-0845
	Mr. Alex Beehler OSD (ESOH)		0845-0915
	Dr. J. Michael Scott University of Idaho		0915-1000
	Dr. Kurt Fristrup Cornell Laboratory of Ornithology		1000-1045
	Mr. Bradley Smith SERDP		1045-1100
Break for Lunch (1100-1300)			
Technical Session 1	Planning and Mitigation	A	1300-1630
	Habitat Modeling and Assessment	B	1300-1630
Poster Reception (1630-1800)			
Evening Mixer (1730-1930)			
Wednesday, June 8			
Registration/Information Desk (0700-1700)			
Continental Breakfast (0800-0830)			
Plenary 2	Mr. Stephen Hodapp ERDC-CERL		0830-0845
	Mr. Dan Ashe USFWS		0845-0915
	Colonel Wayne Thomas ODEP-ACSIM		0915-0945
	Mr. Stephen Hodapp ERDC-CERL		0945-1000
Break (1000-1020)			
Technical Session 2	Invasive Species: Red Imported Fire Ants	A	1020-1200
	Inventory and Monitoring (Part 1)	B	1020-1200
Break for Lunch (1200-1330)			
Technical Session 3	Habitat Management and Manipulation	A	1330-1700
	Inventory and Monitoring (Part 2)	B	1330-1700
Thursday, June 9			
Registration/Information Desk (0700-1230)			
Continental Breakfast (0800-0830)			
Technical Session 4	Impact Assessment	A	0830-1200
	Species and Habitat Conservation	B	0830-1200

Tuesday June 7, 2005				
Session 1A- Planning and Mitigation				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
1300	1310	Opening Remarks	Bill Woodson	U.S. Army Headquarters
1310	1330	Threatened and Endangered Species Document and Data Repository for DoD Installations Using the National Biological Information Infrastructure (NBII)	Robert C. Worrest	U.S. Geological Survey (USGS)
1330	1350	The Makua Implementation Plan: A Comprehensive Species Management Program	David A. Helweg	USGS
1350	1410	Application of Biological Quality Index (BQI) on DoD Lands to Assess Habitat Resiliency to Mission Readiness Activities	Rick Black	HDR, Inc
1410	1430	The Relationship Between Relocation, Stress, and Disease in Gopher Tortoises (*Gopherus polyphermus*)	Paula F. Kahn	Auburn University
1430	**1450**	**Break**		
1450	1510	*Ex situ* Conservation of Threatened and Endangered Plant Species in National Parks, a Collaborative Project between National Park Service and Center for Plant Conservation	Bruce H. Rittenhouse	National Park Service. Biological Resource Management Division
1510	1530	Assessing Army's Conservation Technology Capability Gaps and Potential Solutions	Scott Hill	U.S. Army
1530	1550	Delisting a Threatened Species to Help Sustain the Military Mission	Robert B. Shaw	Colorado State University, Center for Environmental Management of Military Lands
1550	1610	Endangered Species Listing Process- An Analysis of the Seed Band of *Lepidium Papilliferum* (Slickspot Peppergrass), a Proposed Endangered Species	Antonio J. Palazzo	U.S. Army Engineer Research and Development Center
1610	1630	Panel Discussion		

Session 1B: Habitat Modeling and Assessment				
Start	**End**	**Topic/title**	**Speaker**	**Organization**
1300	1310	Opening Remarks	Joan Walker	U.S. Forest Service
1310	1330	Modeling Animal Landscapes	Warren P. Porter	University of Wisconsin-Madison
1330	1350	Identifying Habitat of Rare Species in and Around Military Installations	Virginia Dale	Oak Ridge National Laboratory
1350	1410	Evaluation of Faunal Species of Concern- A Quantitative Approach	Robert O. Wagner	Quantitative Ecological Services, Inc.
1410	1430	LIDAR and Multispectral Imagery for Avian Habitat Assessment	Scott A. Tweddale	U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory
1430	**1450**	**Break**		
1450	1510	Biodiversity of Threatened and Endangered Species on Army Training Lands	Steven D. Warren	Center for Environmental Management of Military Lands, Colorado State University,
1510	1530	Individual Tree Crown Delineation; Tracking RCW Habitat One Tree at a Time	Ryan T. Tombs	Shaw Group, Inc.
1530	1550	The Use of GIS & Decision Support for the Conservation & Management of an Endangered Species: Translocation of the Desert Tortoise from Military Land	Thomas Leuteritz	University of Redlands
1550	1610	Comparison of Threatened & Endangered Resource Issues on Tropical Pacific Ranges	David A. Helweg	U.S. Geological Survey
1610	1630	Panel Discussion		

Wednesday June 8, 2005				
Session 2A: Invasive Species: Red Imported Fire Ants				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
1020	1030	Opening Remarks	Daniel Friese	Air Force Center for Environmental Excellence
1030	1050	Protection of Nesting Black-Capped Vireos form Red Imported Fire Ant Depredation at Fort Hood, Texas	Charles W. Pekins	Fort Hood
1050	1110	Hot Water Treatment for Red Imported Fire Ants (*Solenopsis Invicta*)	G. Robert Myers	Zara Environmental
1110	1130	Management Concerns for Cave Ecosystems in Central Texas	Jean Krejca	Zara Environmental
1130	1200	Panel Discussion		
Session 2B: Inventory & Monitoring (Part 1)				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
1020	1030	Opening Remarks	Paul Dresler	US Geological Survey (USGS)
1030	1050	Developing Information Systems for Species Monitoring Programs	Dwayne A. Hightower	Quantitative Ecological Services, Inc.
1050	1110	Monitoring Threatened and Endangered Species: Incorporation of Spatial Variation and Detectability	Allan F. O'Connell *Presented by Jon D. Klimstra*	USGS--Patuxent Wildlife Research Center
1110	1130	Evaluation of Distance Sampling for Estimating the Abundance of the Black-Capped Vireo on Fort Hood, Texas	David Cimprich *Presented by Thomas Greene*	The Nature Conservatory
1130	1150	Use of Thermal IR Videography for Study of Warm-Blooded T&E Species	Bruce M. Sabol	US Army Engineer Research and Development Center
1150	1200	Panel Discussion		

Session 3A: Habitat Management and Manipulation				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
1330	1340	Opening Remarks	Peter Boice	Office of the Deputy Under Secretary of Defense (Installations & Environment) Conservation
1340	1400	Effects of Forestry Practices on Movement Patterns and Space Used by Gopher Tortoises	Whit Gibbons	The University of Georgia Savannah River Ecology Laboratory
1400	1420	The Forest Ecosystem Study: Creating Biocomplexity in Young, Managed Forests	Todd M. Wilson	U.S. Forest Service
1420	1440	Endangered Bird Monitoring at Marine Corps Base Camp Pendleton	Barbara E. Kus	U.S. Geological Survey
1440	1500	Management of California Least Terns and Western Snowy Plovers on Navy Lands in San Diego Bay	Tamara S. Conkle	Naval Base Coronado
1500	**1520**	**Break**		
1520	1540	The Culvert Test Bed Facility: A Research Tool for Enhancing Fish Passage	Christopher W. May	Pacific Northwest National Laboratory
1540	1600	Response of Gopher Tortoises to Habitat Management by Prescribed Burning at Camp Shelby Training Site, Mississippi	Matthew Hinderliter	The Nature Conservatory
1600	1620	Habitat Management and Population Recovery of Eggert's sunflower (*Helianthus eggertii* Small) on Arnold Air Force Base, Tennessee	Kevin C. Fitch	Arnold Air Force Base
1620	1640	Linking Habitat and Demography for Assessing Species Viability and Evaluating Recovery Targets	H. Resit Akçakaya	Applied Biomathematics
1640	1700	Panel Discussion		

Session 3B: Inventory & Monitoring (Part 2)				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
1330	1340	Opening Remarks	Paul Dresler	U.S. Geological Survey
1340	1400	The Indiana bat on Newport Chemical Depot, Vermillion County: A Fragmented Landscape	Virgil Brack Jr.	Environmental SI
1400	1420	Innovative Techniques for Monitoring Indiana Bat (*Myotis sodalis*) Maternity Populations	Matthew Hohmann	U.S. Army Engineer Research and Development Center (ERDC)/Construction Engineering Research Laboratory (CERL)
1420	1440	Minimizing Uncertainty in Presence/Absence Classification of Rare Salamander Populations	Mark Bevelhimer	Oak Ridge National Laboratory
1440	1500	Using Automated Radio Telemetry and Real-Time Remote Database to Monitor Desert Tortoises	David Delaney	ERDC
1500	**1520**	**Break**		
1520	1540	Analysis of Gopher Tortoise Population Estimation Techniques and Suggestions for Improvement	William D. Meyer	ERDC/CERL
1540	1600	Burrow Dispersion, Population Status, & Impacts Affecting the Gopher Tortoise at Avon Park Air Force Bombing Range	Al Kinlaw	Department of Wildlife Ecology, University of Florida
1600	1620	Home range, movements, and hibernacula location of the timber rattlesnake (*Crotalus horridus*) and northern pine snake (*Pituophis melanoleucus*)	Ronald M. Smith	Drexel University
1620	1640	Habitat Use by the Louisiana Pine Snake at Fort Polk, LA	D. Craig Rudolph	U.S. Forest Service
1640	1700	Panel Discussion		

Thursday, June 9, 2005				
Session 4A: Impact Assessment				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
0830	0840	Opening Remarks	Steve Hodapp	U.S. Army Engineer Research and Development Center (ERDC)/Construction Engineering Research Laboratory
0840	0900	Ecological &Environmental Acoustic Remote Sensor (EcoEARS) Application for Long-Term Monitoring and Assessment of Wildlife	Gonzalo Sanchez	Sanchez Industrial Design, Inc.
0900	0920	Ecological Risk Assessment for TER-S and Wildlife Management	Thomas Smith	ERDC
0920	0940	Quantitative Investigation of Military Training Noise Effects on Bat Activity at Fort Knox, Kentucky	Chester O. Martin	ERDC/Environmental Laboratory
0940	1000	Effects of Transient Training Disturbance on Black-Capped and White-Eyed Vireos on Fort Hood, Texas	Timothy J. Hayden	ERDC
1000	**1020**	**Break**		
1020	1040	Military Smoke and Obscurant Effects on Fish and Wildlife	Thomas Smith	ERDC
1040	1100	Assessing Contaminant Sensitivity of Endangered and Threatened Freshwater Fish and Mussels	Ning Wang	U.S. Geological Survey (USGS)
1100	1120	Tools to Evaluate Management Options for Threatened Fish in the Columbia River Basin	James H. Petersen	USGS
1120	1140	Integrating Soldiers and Skullcaps: Lessons from the Management of a Spring Ephemeral	Laura P. Lecher	Tennessee Army National Guard
1140	1200	Panel Discussion		

Session 4B: Species and Habitat				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
0830	0840	Opening Remarks	Reed F. Noss	University of Central Florida
0840	0900	Conserving Species and Ecosystems	Reed F. Noss	University of Central Florida
0900	0920	Species at Risk on Dept. of Defense Lands: Analysis and Tools for Conservation	Nancy Benton	NatureServe
0920	0940	Developing a Database to Track Status and Trends for Populations	Peter Dratch	National Park Service
0940	1000	Discovery of a New Species on a Military Training Area and its Consequences	Dana Quinney	Idaho Army National Guard
1000	**1020**	**Break**		
1020	1040	Metapopulation Genetic Dynamics of Two Endangered Songbirds	Richard F. Lance	U.S. Army Engineer Research and Development Center
1040	1100	Desert Tortoise Hatchery Project at Edwards Air Force Base	Eric Peffer	CH2M Hill, Inc.
1120	1140	Blandings Turtle Research and Nest Protection at the Camp Ripley ANG Training Site, MN	Julie DeJong	Minnesota Department of Natural Resources
1100	1120	Identifying and Managing Habitat for Endangered Karst Species at Camp Bullis, Texas	George Veni	Texas A&M University
1140	1200	Panel Discussion		

POSTER SESSION		
Title	**Authors**	**Organization**
Study and Management of a Rare Plant on a Military Training Area to Prevent Listing	Dana Quinney	Idaho Army National Guard
Regional Conservation Assessment with a Decision Support System	Bruce Stein	NatureServe
Population Monitoring of the Easter Regal Fritillary, *Speyeria idalia idalia* (Drury) at Indiantown Gap, Annville, Pennsylvania	Betty Ferster	The Nature Conservancy
USGS Research and Monitoring for TES Species: an Overview with Case Studies	Rachel Claire Muir	U.S. Geological Survey
Threatened and Endangered Species Research, the Army's Highest Priority Conservation Research Requirement	Stephen Hodapp	U.S. Army Engineer Research and Development Center
Use of a New England Superfund Site by Two State-Listed Turtle Species	Kirsten Durocher Wandland	ENSR International; U.S. Navy Engineering Facility, Northeast
The Mammalian Fauna of Letterkenny Army Depot, Pennsylvania: Conservation and Restoration Opportunities for Small Mammals	Richard L. Stewart Jr.	Shippensburg University; Letterkenny Army Depot
The Herpetofauna of Letterkenny Army Depot, South Central Pennsylvania: Long Term Monitoring and Management of Amphibians and Reptiles	Pablo R. Delis	Shippensburg University
GIS-based Tests of Spatial Associations Between a Conservation-Sensitive Species and Another Biological Resource or a Potential Anthropogenic Impact	Jean-Luc E. Cartron	SAIC
Slickspot Peppergrass Conservation and Monitoring on Mountain Home Air Force Base, Idaho	Dennis Mengel	CH2M Hill, Mountain Home Air Force Base
The Impact of Military Disturbance on the Habitat and Reproduction of Michaux's Sumac (*Rhus michauxii*)	Verl Emrick	Virginia Tech Conservation Management Institute, Virginia Department of Military Affairs
An Insular Population of Spotted Turtles: Importance of Protected Sites to Population Stability of Long-Lived Species	S. Alexandra Siess	The Tortoise Reserve
Conservation Banking at the Landscape-Scale for the Red-cockaded Woodpecker	Douglas J. Bruggeman	Department of Fisheries & Wildlife, Michigan State University
Online Demonstration: Threatened and Endangered Species Document and Data Repository	John Thigpen	HGL, Inc. (SERDP Program Support)

APPENDIX B:
Symposium Attendee List

Sd.	First Name	Last Name	Title	Organization	City	State
Mr.	Aaron	Addison	GIS Specialist	Zara Environmental LLC	Buda	TX
Dr.	H. Resit	Akcakaya		Applied Biomathematics	Setauket	NY
Mr.	Robert	Anderson		U.S. Army Training and Doctrine Command--Deputy Chief of Staff for Personnel, Infrastructure, and Logistics	Norfolk	VA
Mr.	Dan	Ashe	Science Advisor to the Director	U.S. Fish & Wildlife Service	Washington	DC
Ms.	Pamela	Bailey	Landscape Ecologist	U.S. Army Engineer Research and Development Center--Environmental Lab	Vicksburg	MS
Dr.	Harold	Balbach	Research Biologist	U.S. Army Engineer Research and Development Center	Champaign	IL
Ms.	Cynthia	Bauer	Wildlife Biologist	U.S. Army Environmental Center	Aberdeen Proving Ground	MD
Mr.	Alex	Beehler	Assistant Deputy Under Secretary of Defense	Office of the Secretary of Defense (Environment, Safety and Occupational Health)	Washington	DC
Ms.	Nancy	Benton		NatureServe	Arlington	VA
Dr.	Mark	Bevelhimer		Oak Ridge National Laboratory	Oak Ridge	TN
Dr.	Walter	Bien	Researcher	Drexel University	Philadelphia	PA
Ms.	Angelia	Binder	Chief, Conservation	Mountain Home Air Force Base	Mountain Home AFB	ID
Mr.	Rick	Black		HDR Engineering, Inc.	Salt Lake City	UT
Mr.	John A.	Bleiler		ENSR International	Westford	MA
Mr.	Peter	Boice	Director, Conservation Program	Office of the Deputy Under Secretary of Defense (Installation & Environment) Conservation	Arlington	VA
Dr.	Herb	Bolton	National Program Leader	U.S. Department of Agriculture--Cooperative State, Research, Education, and Extension Service	Washington	DC
Dr.	Virgil	Brack		Environmental Solutions & Innovations, Inc.	Cincinnati	OH
Ms.	Desiree	Bramhall	Environmental Engineer	Raytheon Missile Systems	Tucson	AZ
Mr.	Doug	Bruggeman		Dept. Fisheries & Wildlife, Michigan State University	East Lansing	MI
Mr.	Scot	Bryant	Sr. Project Manager	SAIC	Charlottesville	VA
Mr.	Richard	Bunn	Wildlife Manager	Fort Carson	Fort Carson	CO

Sd.	First Name	Last Name	Title	Organization	City	State
Ms.	Gabrielle	Canonico		U.S. Geological Survey--National Biological Information Infrastructure	Reston	VA
Mrs.	Diane	Cargile	IT Specialist	U.S. Army Engineer Research and Development Center	Vicksburg	MS
Ms.	Tamara	Conkle		U.S. Navy	San Diego	CA
Mr.	Chris	Cottrell		U.S. Army Engineer Research and Development Center	Alexandria	VA
Dr.	Marie	Cottrell	Natural and Cultural Resources Officer	Marine Air Ground Task Force Training Command	Twentynine Palms	CA
Dr.	John	Cullinane	Technical Director	U.S. Army Engineer Research and Development Center	Vicksburg	MS
Dr.	Virginia	Dale	Corporate Fellow	Oak Ridge National Laboratory	Oak Ridge	TN
Ms.	Alison	Dalsimer	Conservation Special Projects	HGL, Inc.	Herndon	VA
Ms.	Kerrin	Dame	Environmental Protection Specialist	U.S. Army Environmental Center	Aberdeen Proving Ground	MD
Mr.	Charles	Davis	Ecologist		Lutherville	MD
Mrs.	Julie	DeJong	Animal Survey Assistant	Minnesota Department of Natural Resources	Little Falls	MN
Mr.	David	Delaney	Research Biologist	U.S. Army Engineer Research and Development Center--Construction Engineering Research Laboratory	Champaign	IL
Dr.	Pablo	Delis	Biology Professor	Shippensburg University	Shippensburg	PA
Dr.	Deidre	DeRoia		Center for Environmental Management of Military Lands	Aberdeen Proving Ground	MD
Ms.	Ann	DiLorenzo	NEPA Analyst	U.S. Army Environmental Center	Aberdeen Proving Ground	MD
Mr.	Chip	Dirth		NatureServe	Arlington	VA
Mr.	Sean	Donahoe		Marstel-Day, LLC	Alexandria	VA
Dr.	Peter	Dratch		National Park Service	Fort Collins	CO
Mr.	Paul	Dresler	Program Coordinator	U.S. Geological Survey	Reston	VA
Mr.	Daniel	Dunn	Chief, Natural Resources	Redstone Arsenal	Redstone Arsenal	AL
Mr.	Verl	Emrick		Conservation Management Institute	Blacksburg	VA
Ms.	Joan	Esarey		Illinois Natural History Survey	Champaign	IL

Sd.	First Name	Last Name	Title	Organization	City	State
Ms.	Colleen	Fahey	Government Affairs Specialist	American Zoo and Aquarium Association	Silver Spring	MD
Dr.	Betty	Ferster	Project Manager	The Nature Conservancy	Annville	PA
Mr.	Kevin	Fitch		Arnold Air Force Base	Arnold AFB	TN
Mr.	Bryan	Foley	Environmental Biologist	Fort Gordon DPWL/ENRMO	Fort Gordon	GA
Ms.	Gina	Foringer	Vice President	Versar, Inc.	Norfolk	VA
Dr.	Daniel	Friese		Air Force Center for Environmental Excellence	Brooks City-Base	TX
Dr.	Kurt	Fristrup	Assistant Director, Bioacoustics	Cornell University	Ithaca	NY
Mr.	Nobime	Georges		Laboratoire d'Ecologie Appliquée	Cotonou	Benin
Dr.	Whit	Gibbons		Savannah River Ecology Laboratory	Aiken	SC
Ms.	Amy	Gilboy	Environmental Scientist	Geo-Marine, Inc.	Newport News	VA
Dr.	Lev	Ginzburg		Applied Biomathematics	Setauket	NY
Mr.	David W.	Goad		Aberdeen Test Center	Aberdeen Proving Ground	MD
Mr.	Lewis	Gorman		U.S. Fish & Wildlife Service--Endangered Species	Arlington	VA
Dr.	Thomas	Greene		The Nature Conservancy	Fort Hood	TX
Mr.	Lawton	Grinter		Fort A.P. Hill	Fort A.P. Hill	VA
Ms.	Shelly	Grow		Butterfly Conservation Initiative	Silver Spring	MD
Ms.	Ami	Gulden	Ecologist	ARM Group Inc.	Hershey	PA
Ms.	Patricia	Hamlett	Sr. Scientist	Tennessee Valley Authority	Chattanooga	TN
Ms.	Mary	Hassel		National Guard Bureau	Arlington	VA
Mr.	Joe	Hautzenroder		Naval Facilities Engineering Command Headquarters	Charlotte Hall	MD
Mr.	Timothy	Hayden	Ecologist	U.S. Army Engineer Research and Development Center	Champaign	IL
Mr.	Thomas	Heffernan	Range Environmental Planner	Eglin Air Force Base--46th Test Wing Plans Office	Eglin Air Force Base	FL
Dr.	David	Helweg		U.S. Geological Survey--Biological Resources Discipline --Pacific Island Ecosystems Research Center	Hawaii National Park	HI
Ms.	Laura	Henze		U.S. Fish & Wildlife Service	Arlington	VA

Sd.	First Name	Last Name	Title	Organization	City	State
Mrs.	Kimberly	Hickey	Natural Resource Specialist	Naval Facilities Engineering Command Headquarters	Washington	DC
Mr.	Dwayne	Hightower		Quantitative Ecological Services, Inc.	DeRidder	LA
Mr.	Matthew	Hinderliter	Gopher Tortoise Biologist	The Nature Conservancy	Camp Shelby	MS
Ms.	Heidi	Hirsh	Natural Resources Specialist	Headquarters U.S. Marine Corps	Washington	DC
Mr.	Steve	Hodapp		U.S. Army Engineer Research and Development Center--Construction Engineering Research Laboratory	Champaign	IL
Mr.	Matthew	Hohmann		U.S. Army Engineer Research and Development Center--Construction Engineering Research Laboratory	Champaign	IL
Dr.	Robert	Holst	Program Manager for Sustainable Infrastructure	SERDP & ESTCP Program Office	Arlington	VA
Mr.	John	Hunt	Environmental Manager	Michigan Army National Guard	Camp Grayling	MI
Mr.	Mark	Indseth	Wildlife Biologist	Ft. A.P. Hill	Ft. A.P. Hill	VA
Mr.	Arthur	Javier	Conservation Manager	Hawaii Army National Guard	Honolulu	HI
Mr.	Steven	Jiang	Information Systems Specialist	HGL, Inc.	Herndon	VA
Mr.	Jeffray	Jones		Virginia Army National Guard	Blackstone	VA
Ms.	Paula	Kahn	Doctoral Candidate	Auburn University	Opelika	AL
Ms.	Tina	Kastner		EDO Corporation	Arlington	VA
Mr.	Frederick S.	Kelley		Versar, Inc.	Columbia	MD
Ms.	Katharine	Kerr	Cultural Resources Management Specialist	HGL, Inc.	Herndon	VA
Mr.	Craig	Kindlin	Natural Resources Manager	Letterkenny Army Depot	Chambersburg	PA
Mr.	Al	Kinlaw	PhD Candidate	University of Florida	Eustis	FL
Mr.	Ronald	Kinlaw		Marine Corps Recruit Depot Parris Island	Parris Island	TN
Mr.	Jon	Klimstra		U.S. Geological Survey--Patuxent Wildlife Research Center	Laurel	MD
Mr.	Mathew	Kramm	Biologist	Randolph Air Force Base	Randolph AFB	TX
Ms.	Beth	Krause		EDO Corporation	Arlington	VA

Sd.	First Name	Last Name	Title	Organization	City	State
Dr.	Jean	Krejca		Zara Environmental, LLC	Buda	TX
Mr.	Alex	Kuli	Associate Editor, Defense Environment Alert	Inside Washington Publishers	Arlington	VA
Dr.	Barbara	Kus	Research Ecologist	U.S. Geological Survey--Western Ecological Research Center	San Diego	CA
Mr.	Richard	Lance		U.S. Army Engineer Research and Development Center	Vicksburg	MS
Mr.	Christopher	Landgraf	Senior Environmental and GIS Consultant	Essex Corporation	Columbia	MD
Mrs.	Laura	Lecher	Natural Resources Manager	Tennessee Army National Guard	Nashville	TN
Dr.	Thomas	Leuteriz		Redlands Institute	Redlands	CA
Ms.	Sherry	Lewis	US Environmental Planning Branch	Booze Allen Hamilton--U.S. Army Environmental Center	Aberdeen Proving Ground	MD
Mr.	John	Luce		Marine Corps Air Station Beaufort	Beaufort	SC
Dr.	Rob	Maher	Associate Professor	Montana State University - Bozeman	Bozeman	MT
Ms.	Peg	Margosian		Avon Park Air Force Range	Avon Park Air Force Range	FL
Dr.	Jeffrey	Marqusee	Director	SERDP & ESTCP Program Office	Arlington	VA
Mr.	Chester	Martin	Research Wildlife Biologist	U.S. Army Engineer Research and Development Center--Environmental Lab	Vicksburg	MS
Ms.	Sarah	Martin	Environmental Scientist	U.S. Army Installation Management Agency--Northeast Region	Fort Monroe	VA
Dr.	Christopher	May	Freshwater Ecologist	Battelle-Pacific Northwest National Laboratory	Sequim	WA
Mr.	Steve	McClung		Sverdrup Technology	Aberdeen Proving Ground	MD
Dr.	Denny	Mengel	Senior Habitat Technologist	CH2M HILL	Boise	ID
Mr.	William	Meyer	Natural Resource Specialist	U.S. Army Engineer Research and Development Center--Construction Engineering Research Laboratory	Champaign	IL

Sd.	First Name	Last Name	Title	Organization	City	State
Mr.	Ben	Miley		Oak Ridge Institute for Science and Education--U.S. Army Environmental Center	Auburn	AL
Mr.	Alan	Mitchnick		Federal Energy Regulatory Commission	Washington	DC
Ms.	Katie	Mittmann		Weston Solutions	Austin	TX
Mr.	Pedro	Morales	Natural Resource Specialist	Legacy Resource Management Program	Arlington	VA
Ms.	Rachel	Muir	Imperiled Species Coordinator	U.S. Geological Survey	Reston	VA
Mr.	Thomas	Mull	Environmental Engineer (Nat Res)	TYBRIN Corporation	Edwards AFB	CA
Ms.	Susan	Murdock	Environmental Scientist	Malcolm Pirnie, Inc.	Newport News	VA
Mr.	Rob	Myers	Biologist	Zara Environmental, LLC	Buda	TX
Mr.	Stan	Norquist		MCB Camp Pendleton	Camp Pendleton	CA
Dr.	Reed	Noss	Professor	University of Central Florida	Orlando	FL
Mr.	Allan	O'Connell	Research Wildlife Biologist	U.S. Geological Survey--Patuxent Wildlife Research Center	Beltsville	MD
Ms.	Jennifer	Ofosu	Student	Eco-consult, Inc.	Accra-north	na
Dr.	Leslie	Orzetti	Environmental Consultant	HGL, Inc.	Herndon	VA
Mr.	Antonio	Palazzo		U.S. Army Engineer Research and Development Center--Construction Engineering Research Laboratory	Hanover	NH
Dr.	Michael	Passmore	C/Ecological Resources Branch	U.S. Army Engineer Research and Development Center--Environmental Laboratory	Vicksburg	MS
Mr.	John	Paul	Environmental Protection Specialist	Aberdeen Proving Ground--Directorate of Safety, Health and Environment	Aberdeen Proving Ground	MD
Mr.	Eric	Peffer	Biologist	CH2M HILL	Edwards AFB	CA
Mr.	Charles	Pekins	Wildlife Biologist	Fort Hood--Natural Resources Management Branch	Fort Hood	TX
Dr.	Jim	Petersen		U.S. Geological Survey	Cook	WA
Mrs.	Karen	Phillips		U.S. Geological Survey	Sacramento	CA
Mr.	John	Pilcicki	Wildlife Biologist	SpecPro	Herndon	VA
Mr.	Jonathan	Poe		Oak Ridge Institute for Science and Education--U.S. Army Environmental Center	Waverly Hall	GA

Sd.	First Name	Last Name	Title	Organization	City	State
Dr.	Warren	Porter	Prof. of Zoology	University of Wisconsin	Madison	WI
Ms.	Cynthia	Pritekel		The Nature Conservancy	Annville	PA
Ms.	Stacy	Prosser	ITAM Manager	Hawaii Army National Guard	Honolulu	HI
Mr.	Scott	Pruitt	Field Supervisor	U.S. Fish & Wildlife Service	Bloomington	IN
Mrs.	Dana	Quinney		Idaho Army National Guard	Boise	ID
Mr.	Scott	Quinney		Idaho Army National Guard	Boise	ID
Mrs.	Jill	Reilly Hauck		SAIC	Abingdon	MD
Ms.	Veronica	Rice	Meeting Coordinator	HGL, Inc.	Herndon	VA
Mr.	Stanley	Rikard		Fort Jackson--Wildlife Office	Fort Jackson	SC
Dr.	J. Douglas	Ripley	Senior Environmental Professional	Engineering-Environmental Management, Inc.	Fairfax	VA
Mr.	Bruce	Rittenhouse		National Park Service	Fort Collins	CO
Mr.	Jay	Rubinoff		U.S. Army Environmental Center	Aberdeen Proving Ground	MD
Dr.	Daniel	Rudolph	Research Ecologist	U.S. Forest Service--Southern Research Station	Nacogdoches	TX
Ms.	Jennifer	Rusk	SERDP/ESTCP Database Administrator	HGL, Inc.	Herndon	VA
Mr.	Bruce	Sabol		U.S. Army Engineer Research and Development Center	Vicksburg	MS
Mr.	Gonzalo	Sanchez	President - Engineer	Sanchez Industrial Design Inc.	Middleton	WI
Ms.	Lorri	Schwartz	Natural Resources Specialist	Naval Facilities Engineering Command Headquarters	Washington	DC
Dr.	J. Michael	Scott		University of Idaho--Idaho Cooperative Fish and Wildlife Research Unit	Moscow	ID
Mr.	Steve	Sekscienski	Wildlife Biologist	U.S. Army Environmental Center	Aberdeen Proving Ground	MD
Dr.	Robert	Shaw	Director & Professor	Center for Environmental Management of Military Lands	Fort Collins	CO
Ms.	Alicia	Shepard	Associate Conservation Specialist	HGL, Inc.	Herndon	VA
Ms.	S. Alexandra	Siess		George Washington University	Arlington	VA
Ms.	Myra	Sinnott		Defenders of Wildlife	Washington	DC
Mr.	Bradley	Smith	SERDP Executive Director	SERDP & ESTCP Program Office	Arlington	VA

Sd.	First Name	Last Name	Title	Organization	City	State
Mr.	Brian	Smith		Federal Highway Administration--Resource Center	Olympia Fields	IL
Dr.	Graham	Smith	Research Manager	U.S. Geological Survey--Patuxent Wildlife Research Center	Laurel	MD
Mrs.	Jackie	Smith	Natural Resources Specialist	Naval Air Station Patuxent River	Patuxent River	MD
Mr.	Ronald	Smith		Drexel University	Langhorne	PA
Mr.	Thomas	Smith		U.S. Army Engineer Research and Development Center--Construction Engineering Research Laboratory	Champaign	IL
Mr.	Rick	Spaulding	Senior Wildlife Biologist	TEC, Inc.	Bainbridge Island	WA
Dr.	Bruce	Stein	Vice President for Programs	NatureServe	Arlington	VA
Dr.	Richard	Stewart	Assistant Professor of Biology	Shippensburg University	Shippensburg	PA
Dr.	Lawrence	Stritch	Botanist	U.S. Forest Service	Shepherds-town	WV
Dr.	David	Tazik	Ecologist	U.S. Army Engineer Research and Development Center	Vicksburg	MS
Mr.	Craig E.	Ten Brink		MCB Camp Lejeune	Camp Lejeune	NC
Mr.	John	Thigpen	Project Assistant, Conservation	HGL, Inc.	Herndon	VA
Dr.	Wayne	Thogmartin	Quantitative Ecologist	U.S. Geological Survey--Upper Midwest Environmental Sciences Center	La Crosse	WI
Mr.	Jerry	Thompson		Essex Corporation	Columbia	MD
Mr.	Mark	Thornton		Fort Benning	Fort Benning	GA
Mr.	Ryan	Tombs	GIS Manager	Shaw Environmental and Infrastructure, Inc.	Concord	CA
Mr.	Ronnie	Torres	GIS Administrator	Hawaii Army National Guard	Honolulu	HI
Mr.	John	Townson	Natural Resource Manager	Marine Corps Base Camp Lejeune	Camp Lejeune	NC
Mr.	Jonathan	Van De Venter	Natural Resource Manager	Picatinny Arsenal	Picatinny Arsenal	NJ
Dr.	Beatrice	Van Horne		U.S. Forest Service--Research and Development	Washington	DC
Dr.	George	Veni		George Veni & Associates	San Antonio	TX
Mr.	Larry	Vrtiska	Natural Resource Manager	Army National Guard	Ashland	NE

Sd.	First Name	Last Name	Title	Organization	City	State
Dr.	Robert	Wagner		Quantitative Ecological Services, Inc.	DeRidder	LA
Dr.	Joan	Walker	Research Plant Ecologist	U.S. Forest Service--Southern Research Station	Clemson	SC
Ms.	Meegan	Wallace	Environmental Project Manager	Geo-Marine, Inc	Newport News	VA
Ms.	Kristen	Wandland		ENSR	Raleigh	NC
Mr.	Ning	Wang	Research Fisheries Biologist	U.S. Geological Survey--Columbia Environmental Research Center	Columbia	MO
Mr.	Robert	Wardwell	Management Agronomist	U.S. Army--Adelphi Laboratory Center	Adelphi	MD
Dr.	Steven	Warren	Research Scientist	Center for Environmental Management of Military Lands	Fort Collins	CO
Mr.	Jay	Weaver		Idaho Army National Guard	Boise	ID
Dr.	John	Wiens	Chief Scientist	The Nature Conservancy	Arlington	VA
Ms.	Beattie	Williams		Applied Research Associates	Vicksburg	MS
Mr.	Todd	Wilson	Wildlife Biologist	U.S. Forest Service--Pacific Northwest Research Station	Olympia	WA
Mr.	William	Woodson		U.S. Army--Office of the Director of Environmental Programs	Washington	DC
Dr.	Robert	Worrest	Chief Scientist, NBII	U.S. Geological Survey--National Biological Information Infrastructure	Reston	VA
Mrs.	Janna	Yoo	Research Biologist	U.S. Army Engineer Research and Development Center	Vicksburg	MS

APPENDIX C:
Plenary Session Speaker Biosketches

Mr. Alex A. Beehler
Assistant Deputy Under Secretary of Defense (Environment, Safety and Occupational Health)

Alex A. Beehler commenced as Assistant Deputy Under Secretary of Defense (Environment, Safety and Occupational Health) on January 5, 2004. Mr. Beehler serves as the principal assistant and advisor to Deputy Under Secretary Grone for all environmental, safety, and occupational health policies and programs in DoD. Those programs include cleanup at active and closing bases, compliance with environmental laws, conservation of natural and cultural resources, pollution prevention, environmental technology, fire protection, safety and explosive safety, and pest management and disease control for Defense activities worldwide. He also advises Mr. Grone on international military agreements and programs pertaining to environmental security.

Mr. Beehler's priorities includes the implementation of DoD's environmental readiness initiative in response to challenges of encroachment, the Defense Environmental Restoration Program, unexploded ordnance management, explosive safety, and pollution prevention.

Mr. Beehler comes to the department from Koch Industries where he served as Director of Environmental and Regulatory Affairs and concurrently served at the Charles G. Koch Foundation as Vice President for Environmental Projects. Mr. Beehler maintains a strong background in federal environmental policy having served in the Department of Justice as a senior trial attorney for environmental enforcement and at the Environmental Protection Agency as a special assistant for legal and enforcement counsel.

Mr. Beehler is a member of the District of Columbia, State of Maryland and Commonwealth of Virginia bar associations. He received a bachelor’s degree from Princeton (1975) in public and international affairs and a law degree from University of Virginia (1978).

Dr. J. Michael Scott
Fish and Wildlife Resources
University of Idaho

From 1974 to 1984, Dr. J. Michael Scott served as a Research Biologist for the US Fish and Wildlife Service at Mauna Loa Field Station, Hawaii Volcanoes National Park. This was his first assignment with the US Department of Interior, the agency he continues to serve today as a Senior Scientist with the Biological Resources Division of the US Geological Survey. From 1984 to 1986, he served as Project Leader of the Condor Research Center in Ventura, California. In 1986 he was appointed to the position he holds at present, Leader of the Idaho Cooperative Fish and Wildlife Research Unit in Moscow, Idaho. In addition, he is a Professor in the Department of Fish and Wildlife Resources at the University of Idaho, where he pioneered the Gap Analysis Program and served as Program Leader from 1989-1997.

Dr. Scott's dedication and success in developing the Gap Analysis Program is indicative of his professional life and goals. By comparing information on distribution of vertebrates, invertebrates, and native vegetation with the distribution of managed areas, the Gap program enables land managers to determine how many ecosystem types and species are under protected. The underlying assumption is that many species will be threatened or endangered in the future unless steps are taken to protect them and their habitats, and that the time to protect species is when they are common.

Dr. Scott and his graduate students are currently conducting research on topics as diverse as recovery of endangered species; diversity, integrity, and health of wildlife populations on National Wildlife Refuges; and effectiveness of current nature reserves in protecting the biodiversity of America.

Dr. Scott has authored and co-authored more than 150 journal articles, books, book chapters, and monographs on topics as wide-ranging as reserve identification, selection and design; tuna schooling behavior; endangered species recovery; avian population estimation; and landscape approaches to conservation biology. He co-authored *Forest bird communities of the Hawaiian Islands: their dynamics, ecology, and conservation* (1986), which received The Wildlife Society's Best Monograph Award. In addition, Dr. Scott has edited six books including: *Estimating number of terrestrial birds* (1986, with C.J. Ralph), *Evolution, ecology, conservation and management of Hawaiian birds: A vanishing avifauna* (2001, with S. Conant and C. Van Ripper III), *Predicting species occurrences: Issues of accuracy and scale* (2002 , with Pat Hegland and others), and *The Endangered Species Act at 30: Lessons and Prospects* (2005, with D. Goble and F.W. Davis).

Dr. Scott’s professional accomplishments have been recognized by the Society for Conservation Biology with both the Distinguished Achievement Award and the Edward T. La Roe III Memorial Award. He has received a Meritorious Service Award from the US Department of Interior and a Twentieth Century Environmental Achiever Award at the Ninth Lukac's Symposium. He is an elected fellow of the American Association for the Advancement of Science and the American Ornithologist's Union. Dr. Scott is a past President of both the Cooper Ornithological Society and the Pacific Seabird Group, and has served on the Boards of a number of professional societies.

Dr. Kurt Fristrup
Bioacoustics Research Laboratory
Cornell Laboratory of Ornithology

Kurt Fristrup pursued his undergraduate education in Biomedical Engineering at University of California, San Diego (UCSD), and subsequently pursued his doctoral degree in Evolutionary Biology at Harvard University. He worked at Woods Hole Oceanographic Institution for ten years, focusing on acoustical and radio telemetry studies of whales with Bill Watkins and Peter Tyack. In 1995 he joined the Bioacoustics Research Program at the Cornell Laboratory of Ornithology, continuing his whale acoustical research with Chris Clark.

Dr. Fristrup's recent research has increasingly shifted to terrestrial environments, but continues to focus on the development and application of advanced instrumentation to study animal behavior and ecology.

Mr. Dan Ashe
Science Advisor to the Director
US Fish and Wildlife Service

Dan Ashe is the Science Advisor to the Director of the US Fish and Wildlife Service. He was appointed to this position in March 2003, and advises the Director on the application of science in support of the agency mission. From 1998 to 2003, Mr. Ashe served as the Chief of the National Wildlife Refuge System, directing operation and management of the 93 million-acre National Wildlife Refuge System, and the Service's land acquisition program. During his tenure as Chief, the Refuge System experienced an unprecedented and sustained period of budget increases for operations, maintenance, construction and land acquisition. From 1998 to 2000, Mr. Ashe also directed the Service's migratory bird management and North American wetlands conservation programs. From 1995 to 1998, Mr. Ashe served as the Fish and Wildlife Service's Assistant Director for External Affairs where he directed the agency's programs in legislative, public, and Native American affairs, research coordination, and state grants-in-aid. From 1982 until 1995, Mr. Ashe was a Member of the Professional Staff of the former Committee on Merchant Marine and Fisheries, in the US House of Representatives.

In 13 years on Capitol Hill, Mr. Ashe served in several capacities, advising the Committee's Chairmen and Members on a wide range of environmental policy issues, including endangered species and biodiversity conservation, ocean and coastal resources protection, the National Wildlife Refuge System, the National Marine Sanctuaries Program, the Clean Water Act, wetlands conservation, fisheries management and conservation, and offshore oil and gas development. In 1982, Mr. Ashe was awarded a National Sea Grant Congressional Fellowship.

Mr. Ashe earned a graduate degree in Marine Affairs from the University of Washington in Seattle, where he studied under a fellowship from the Jessie Smith Noyes Foundation, and a B.S. in biological sciences from Florida State University. Mr. Ashe is very active in local civic affairs in Montgomery County, MD, where he and his family reside. Mr. Ashe's father, William (Bill) C. Ashe, was also a career employee of the US Fish and Wildlife Service.

Colonel Wayne Thomas
Chief, Training Support Division (ODEP)
Office of the Assistant Chief of Staff for Installation Management

Colonel Wayne Thomas is an Engineer Officer in the US Army Reserve. At the time of this Symposium, he was assigned to Headquarters Department of Army serving as Chief of the Training Support Division, Directorate of Environmental Programs, Assistant Chief of Staff for Installation Management. Colonel Thomas has served the Army for 26 years, 20 years on Active Duty and 6 years as a citizen Soldier. He has served in Germany, Fort Polk, LA, Presidio of San Francisco, CA, Fort Totten, NY, Fort Benning, GA, and Marion, IL. Prior to his current position, Colonel Thomas served at the Training and Doctrine Command in Fort Monroe, VA. He has numerous decorations and awards including Meritorious Service Medal, Joint Service Commendation Medal, Army Commendation Medal, and Army Superior Unit Award.

Colonel Thomas is a licensed Professional Engineer in Virginia and received a BS degree from Virginia Polytechnic Institute and State University. His civilian career included working for the US Forest Service in Illinois and the Air Force in Minnesota.

APPENDIX D:
Technical Session Speaker Biosketches and Abstracts

SESSION 1A: PLANNING AND MITIGATION

Opening Remarks- Bill Woodson, US Army Headquarters

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Bill Woodson is the sole employee of Bill Woodson Conservation Consultants serving the Army Office of the Director of Environmental Programs (ODEP), Assistant Chief of Staff for Installation Management, through an agreement with Versar, Inc. He has been in this position for just over 2 years. Prior to that, he served 5 years on the Army Staff as a natural resources specialist with ODEP.

Bill serves on the Director's Conservation Team in the Training Support Division. As part of his duties for ODEP, Bill participates in oversight of science and technology for threatened, endangered, and at risk species management. He hopes for improved integration of threatened, endangered, and at risk species research and monitoring among the Army, Department of Defense, and other federal agencies

Bill has a BS in Forestry from Virginia Tech (1969) and an MS in Environmental Planning from the University of Iowa (1994).

Threatened and Endangered Species Document and Data Repository for DoD Installations Using the National Biological Information Infrastructure (NBII)

Dr. Robert C. Worrest; Chief Scientist, National Biological Information Infrastructure; USGS, 12201 Sunrise Valley Drive (MS-302), Reston, VA 20192 ; Tel.: (703) 648-4074; Fax: (703) 648-4098; rworrest@usgs.gov

Co-Authors- Michael Frame; John Mosesso; Donna Roy; John Hill, Ph.D.; Alison Dalsimer; Alicia Shepard

Dr. Worrest (Senior Research Scientist, Columbia University and CIESIN's Associate Director for Washington Operations) is currently on detail at the US Geological Survey serving as Chief Scientist for NBII. For the 7 years prior to this detail, he was the Director of the US Global Change Research Information Office. Dr. Worrest has more than 30 years of experience in ecological research and assessment related to environmental change and variability. He has numerous publications regarding the effects of stratospheric ozone depletion on the biosphere. He is a member of the United Nations Environment Programme (UNEP) Assessment Panel on Environmental Effects of Ozone Depletion. He co-authored the chapter, "Research and Systematic Observation," in the US Climate Action Report 2002: Third National Communication of the United States of America Under the United Nations Framework Convention on Climate Change. *In addition, he contributed to the Climatic Impact Assessment Program related to potential impacts of SSTs on the ozone layer and was a member of the US delegation for the UNEP Coordinating Committee on the Ozone Layer. In 1997, at the tenth anniversary celebration of the Montreal Protocol, he was awarded the UNEP Global Ozone Award for outstanding service.*

The purposes of the Threatened and Endangered Species Document and Data Repository are to:

- Establish a standard methodology and infrastructure for the collection, storage, integration, and retrieval of DoD biological, geophysical, cultural, and historical resources and information;
- Establish a strategy, plan, and priority list for managing biological, geophysical, cultural, and historical resources and information; and
- Help protect significant biological systems and species, including those on the Endangered Species List by providing a consolidated reference tool for DoD and other resource Managers.

By implementing this project, DoD and NBII both benefit by: 1) making threatened and endangered species (TES) data and information available for management and planning purposes; 2) producing useful products in a short time frame using an operational online system; and 3) identifying long-term collaborative opportunities between DoD, NBII, and the many national and international NBII partners.
This project builds on existing TES efforts that were initially focused on US Army prioritized TES species of interest and a subset of TES-related documents (e.g., Endangered Species Management Plans, Biological Opinions). Full implementation of this project will expand the current efforts to include: 1) a broader involvement by and greater incorporation of data for all DoD installations facing TES issues; 2) access to additional document and data types; and 3) development of an operational model information system for other cross-installation and cross-service conservation issues.

NBII has the capability and capacity to provide valuable data on the nation's living resources and infrastructure services to support DoD and the services in meeting training and testing mission requirements. TES can impact core DoD activities. DoD resource managers need TES data for their installation, as well as TES data (including geospatial) from relevant non-DoD sources and TES species distribution maps at regional and national levels. The proposed study developed and is implementing an operational, all DoD services/installation, TES document, data, and information repository that has national infrastructure support from the NBII. This capability can be easily expanded to address other biological issues (e.g., invasive species, human/wildlife diseases, fire management, encroachment).

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The Makua Implementation Plan:
A Comprehensive Species Management Program

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Co-author- James D. Jacobi, Ph.D.

David A. Helweg is Deputy Director of the Pacific Island Ecosystems Research Center of the US Geological Survey. The mandate of this USGS biology research center extends from Hawaii across the islands, atolls, and near shore ecosystems of oceania. He received his Ph.D. from the University of Hawaii in 1993, his M.A. from the University of Hawaii in 1989, and his B.A. from Amherst College in 1981. Dr. Helweg has studied comparative socioecology and bioacoustics in marine mammals, and has introduced several new methods for analysis and automated classification of animal vocalizations. He has over 40 publications in the domains of animal biosonar, bioacoustics, and behavioral biology, and is a member of the Acoustical Society of America and the American Institute of Biological Sciences.

As a result of a Section 7 consultation with the USFWS, the Department of Army identified 30 endangered species (29 plants and 1 snail) that may be jeopardized by continued military training at the Makua Military Reservation (MMR), located on the northwestern side of O`ahu, Hawai`i. These species have significant portions of their known distribution on the MMR or adjacent lands that comprise the Makua Action Area. The Army established a team of agency representatives, adjacent landowner representatives, and biological experts to help design and oversee the implementation of a plan to stabilize all of the affected species so military training activities could continue. This team met over 250 times to put together the Makua Implementation Plan (IP). The process of developing the IP involved detailed research and discussions addressing many areas of species conservation including definition of a population unit and what constitutes stability of a species; the role of in situ and ex situ management actions; population maintenance, augmentation, and reintroduction; alien species management and habitat restoration;, as well as developing reintroduction standards and guidelines that address population genetics and preventing alien pathogens from being dispersed as a result of species reintroductions.

Application of Biological Quality Index (BQl) on DoD Lands to Assess Habitat Resiliency to Mission Readiness Activities

Mr. Rick Black, National Biology Director; HDR Engineering, Inc., 3995 South, 700 East, Suite 100, Salt Lake City, UT 84107; Tel: (801) 743-7831; rick.black@hdrinc.com Co-author- Kris Gruwell

Mr. Black is currently the National Biology Director for HDR Engineering, Inc., in Salt Lake City, Utah. He received a B.S. in Range and Wildlife Ecology at Brigham Young (1984) and an M.S. in Community Ecology. While pursuing his Masters degree, Rick also pursued Graduate Studies in the Education Department at BYU. His Doctoral Studies in Physiological Plant Ecology took him to Texas A&M University. While in Texas, Rick started his consulting career. He currently has more than 20 years of ecological research and consulting experience, and a diverse background in biology, ecology, policy, and technical fields. His biological technical experience includes TES surveys, monitoring, habitat assessment, and impact analyses; and biological assessments, wetland delineations, riparian impacts analyses, vegetation community analyses, ecological risk assessments, and revegetation research and analyses. His community analysis experience has centered on sustainability, revegetation and habitat fragmentation, as well as impacts to sensitive and unique habitats. He has extensive experience in Utah, and has worked with Dugway Proving Ground (DPG) developing methods to analyze quality of habitat and potential for resiliency following ground disturbance, and developed a base-wide multiple species habitat management plan in which a Terrestrial Index of Biological Integrity was developed. This is now used to predict and track the habitat resiliency following mission activities.

HDR Engineering, Inc. was contracted by the US Army to conduct biological surveys prior to testing of the Stryker vehicle at DPG. The purpose was to assess the ecological health status and the degree of wildlife usage of specific areas within DPG. After these assessments were completed and the data were analyzed, recommendations were made suggesting which areas, if any, are at risk for ecological degradation following disturbance and should be protected. DPG occupies 798,214 acres in western Utah, located ~75 mi southwest of Salt Lake City. It is positioned in the eastern subdivision of the Great Basin and Range Province, and in the north-central part of the (Lake) Bonneville Basin (Cronquist and others 1972). It has often been referred to as the Great Salt Lake Desert and is the driest, most ecophysiologically stressful, and seemingly most barren part of the Great Basin (Van Pelt 1993). The natural legacy of DPG can be summarized as consisting of: a striking desert island-mountain with lithologic features unduplicated in Utah; extensive, geomorphologically and floristically varied sand dune fields; large expanses of salt-desert shrub vegetation in high seral condition, some with an intact microfloral crust and unusual ripple patterns; and pristine mountain ridges and sideslopes.

Ecological and wildlife surveys were conducted to meet the primary project objectives, including to: assess plant community health and vigor and susceptibility to invasive species; assess erosion potential and health of cryptobiotic crust; report the significance of each ecoregion/survey area in relation to Great Basin floristics, ecology, and biogeography; determine the presence, distribution, and abundance of noxious weeds and other invasive plant species; characterize locations of desert kit fox (*Vulpes macrotis*) dens and burrowing owl (*Athene cunicularia*) burrows; conduct plant community analysis and rank plant communities based on their character; and recommend management strategies to promote conservation of significant biological and natural resources on DPG lands in relation to the Stryker and JSLSCAD projects. BQI was developed using metrics important to this ecosystem and to the management goals. In this method, metrics are considered to be attributes within a system known (or hypothesized) to be correlated with disturbance. The original IBI (Karr 1991) was developed for use with warm-water streams in the central United States. Many researchers argue that a multi-metric index of biological integrity better indicates disturbance on communities than using principal components analysis (PCA) of species composition or using a single-species indicator (Fore et. al, 1996; Karr and Chu, 1998). Forty-three plots totaling over 9,000 acres (37 km^2) were analyzed using eight separate metrics and combined into a single BQI. The 43 sites were ranked according to their BQI and separated into five BQI Classes. Each of the five classes were defined ecologically, and the five study areas which fell into the top two classes of Biological Quality were singled out. These were considered unique or highly sensitive to disturbance and therefore protected from Stryker testing. Management allowed full testing of the Stryker on the area represented by the remaining 35 plots to further promote mission readiness.

The Relationship Between Relocation, Stress, and Disease in Gopher Tortoises

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Co-Author- Dr. Mary Mandonca

Paula Kahn is a doctoral candidate at Auburn University. She has worked with gopher tortoises for the past four years. Her dissertation focuses on the conservation of these animals by examining the effects of relocation on endocrine and immune parameters. She has conducted her research in Alabama, Georgia, and Mississippi on public, private, and military lands. She anticipates graduating with her PhD in December of this year.

Dr. Mary Mendonça (co-author) is an Associate Professor at Auburn University. Her research centers on how proximate environmental factors and physiological mechanisms are integrated at the neural level to control timing of seasonal reproduction. She also investigates the effects of a variety of environmental stressors (e.g. pollutants, habitat disturbance) on reproductive processes, stress responsiveness, and immunocompetence in amphibians and reptiles, as well as in birds and mammals.

The gopher tortoise (*Gopherus polyphemus*) is a threatened species (TS) found in numerous locations in the southeastern United States, including many DoD lands. Declines in gopher tortoise populations across its range have been attributed to extensive habitat loss, primarily resulting from real estate development. Furthermore, many gopher tortoises are infected with *Mycoplasma agassizii*, the bacterium that causes Upper Respiratory Tract Disease (URTD). Symptomatic URTD has the potential to cause mortality in these animals and is, therefore, considered another factor possibly associated with population declines. Development of effective conservation tools that address both the health and habitat needs of gopher tortoises is critical for their survival. Currently, relocation is the method used most frequently to protect these animals. However, no studies have yet been conducted to determine how the tortoises respond physiologically to relocation. Many animals, reptiles in particular, are sensitive to relocation. In fact, many suffer impaired health and mortality, even when relocations are conducted over short periods of time or distance. In these cases, changes in disease status have been associated with increases in corticosterone, the hormone associated with the stress response. Studies in many species have shown links between the physiological systems controlling the stress response, immunocompetence and reproduction. Therefore, if relocation is a stressful event for tortoises, they may then experience high levels of corticosterone that can lead to compromised immune responses. This series of physiological events can be detrimental to gopher tortoise populations as it could increase their vulnerability to URTD. As a result, relocation, the very tool we use to try to protect the tortoises, may cause changes in stress, immunocompetence, and disease status that could lead to further population declines for this already TS.

We conducted a study at Ft. Benning, Georgia in 2003 and 2004 to determine the physiological effects of relocation on gopher tortoises. We measured corticosterone levels and immune responsiveness in these animals pre- and post-relocation. Specifically, just before and 30 days after relocation, we collected blood samples to determine baseline levels of corticosterone and we measured the tortoises' adrenal responsiveness using an ACTH (adrenocorticotropic hormone) challenge. We also conducted several tests of immune responsiveness. To examine the T cell response, we conducted a PHA (phytohemagglutinin) challenge in which we measured swelling at the site of subcutaneous injection. T cell responses were further quantified using biopsy punches of the swelling. In addition, we examined each tortoise using a health profile for the presence of symptoms related to URTD. The results from these endocrine and immune challenges, combined with the results of the health assessments, will assist us in determining the physiological effects of relocation on gopher tortoises. We anticipate that our findings may be useful in planning for the conservation and management of gopher tortoises, both on and off Department of Defense lands. In addition, since habitat destruction continues to put many species at risk, we hope that our methods may be useful to others in assessing the health status of closely related species, such as the desert tortoise, and the conservation efforts used to protect them.

Ex Situ Conservation of Threatened and Endangered Plant Species in National Parks

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Bruce has over 15 years of experience in plant conservation working with the federal government and is currently the Endangered Species Botanist in the Washington Office for the National Park Service located in Fort Collins Colorado. Prior to that, he was with the Bureau of Land Management in Portland Oregon as program lead for conducting regional surveys for over 400 rare plant and animal species as a part of the Northwest Forest Plan. He has also worked with the BLM and the Forest Service in Oregon for over 10 years working with rare plant species. He received a Master's Degree from Idaho State University in Plant Ecology and a Bachelor's Degree in Botany from Oregon State University.

The National Park Service currently has 196 threatened, endangered and candidate plant species occurring in 67 national parks. Approximately 60% of these species occur within parks in the states of Hawaii, California, and Florida. The most serious endangered plant species crisis is currently in Hawaii where 87 plant species in National Parks are currently listed under the Endangered Species Act. While in situ conservation is the preferred method to prevent the extinction of plant species, ex situ conservation can be one component of an integrated conservation plan to enhance the long-term survival and restoration of many rare plant species. Until recently there was a reluctance to utilize ex situ methods as a conservation tool as it was perceived that ex situ methods would undermine in situ conservation efforts and many conservationists lacked confidence that ex situ methods could be successful. These perceptions have changed over time as more ex situ facilities and botanical gardens have now become more conservation oriented. Many recovery plans for listed plant species now include ex situ conservation as a task to meet recovery goals.

The ultimate goal of ex situ plant conservation is to provide sufficient material to establish new populations, reintroduce or augment existing populations in habitats within the species historical range. Off-site breeding programs have been successful for some animal species such as California condors, and are now being employed for rare plant species. Collecting a genetic representation of the species can act as a genetic safety net for rare species if they become extirpated due to perturbations or stochastic events. For very rare species, such as many Hawai'i species which number less than 10 individuals the objective is just to preserve the remaining genetic material. Through a cooperative agreement the National Park Service is working with the Center for Plant Conservation (CPC) to collect and store seeds of all federally listed plant species occurring on Park Service lands. The CPC is composed of a network of 33 botanical gardens across the United States with the mission to conserve and restore rare native plant species. Collection methods will follow CPC guidelines but the amount of seed collected will vary among species depending on the purposes of collection. The objectives for some species include long term storage of seeds in seed banks, while for others it is to develop germination and propagation protocols or determine if seeds are capable of storage, and finally to use collected seeds in restoration projects. Seeds capable of storage will be stored at the National Center for Genetic Resource Preservation in Fort Collins, CO. Land management agencies, including the Department of Defense, that manage rare plant species should consider ex situ plant conservation as a method to complement current in situ conservation methods. This collaboration between the National Park Service and CPC provides a model that other agencies can use.

Assessing Army's Conservation Technology Capability Gaps and Potential Solutions

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Scott Hill is an Environmental Engineer with the US Army Environmental Center (USAEC) where he manages the Army Environmental Technology Requirements and Technology Assessments (AERTA) process for the Army Environmental Quality Technology Program. Mr. Hill also has supported the Strategic Environmental Research and Development Program and the Environmental Security Technology Certification Program in the areas of Pollution Prevention, Conservation and Compliance. His technical focus areas include Technology Transfer, Hazard and Risk Assessment Methods and Models, Cultural and Natural Resource Technology Advancements, and Innovative Water Treatment Technologies Transfer and Demonstration. He previously served as the Department of Defense's lead project manager for the development of the Range Rule Risk Methodology (R3M), served as a project manager for BRAC environmental restoration programs and worked as an environmental and risk management consultant in the private sector.

Conservation issues at military installations are a significant component to the ongoing encroachment concerns. Successful implementation of the Army's conservation program requires effective engagement of the science and technology community in understanding what the user community already knows about existing specific technology gaps. The Army's Environmental Quality Technology (EQT) program is the management mechanism that the Army uses to set priorities, identify capability gaps, focus resources, and ensure cost efficient investment for technology maturation, transfer, and exploitation. The EQT program's objective is to provide guidance and direction to the Army's environmental community, focusing on science, technology and demonstration and validation work to satisfy user needs. The Army's maintains an information base of validated capability gaps and related data called Army Environmental Requirements and Technology Assessments (AERTA). This paper will provide a review of capability gaps that are contained in AERTA that are related to environmental conservation with particular attention to threatened and endangered species concerns and invasive species control. Included in this discussion will be a summary of the process used to identify the capability gaps and how efforts are then coordinated to select and implement viable solutions in the field.

Delisting a Threatened Species to Help Sustain the Military Mission

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Co-Author- Jeremy Markuson

Dr. Robert B. Shaw is Professor in the Forest, Rangeland, and Watershed Stewardship Department, and Founder and Director of the Center for Environmental Management of Military Lands (CEMML) at Colorado State University. Bob has been working on military land management issues for the last 20 years. Many of those years have been spent searching for, researching, and protecting rare plants species on military lands. He began investigations on the Big Island of Hawaii at the US Army's Pohakuloa Training Area in 1988; where new species, previously thought extinct species, and tens of thousands of threatened and endangered plants have been documented. Much of the Center's work in this area has repeatedly demonstrated the need for more extensive and thorough biological surveys for environmental documents such as Environmental Assessments (EA) and Environmental Impact Statements (EIS). Bob's graduate degrees are from Texas A&M University and his undergraduate degree is from Southwest Texas State University. He is a veteran of the Viet Nam era, and served in the US Navy.

Mr. Jeremy Markuson is a graduate student in the Forest, Rangeland, and Watershed Stewardship Department at Colorado State University. He is responsible for the more recent research expeditions in search of Silene hawaiiensis. Jeremy earned his B.S. degree in Natural Resource Management from CSU.

There are various reasons that a taxon can be removed (i.e., delisted) from the endangered and threatened species list. Delisting can occur because: 1) of taxonomic revision; 2) of recovered; 3) of extinction; 4) of new evidence of additional populations, etc. This study was undertaken to investigate the feasibility of delisting a species to enhance training on a US Army installation. Military training on the US Army Pohakuloa Training Area (PTA), Hawaii is greatly restricted by the presence of numerous threatened and endangered species. Over 20 rare taxa are known to inhabit PTA, and the species are wide-spread across the installation. *Silene hawaiiensis* (Hawaiian catchfly) is a threatened taxon that is the most ubiquitous rare plant on the installation. Its presence in the training area impacts live fire, maneuvering, and construction of new facilities (especially roads and firing ranges).

Silene hawaiiensis is a perennial, erect or sprawling shrub with multiple stems arising from a large, tuber-shaped taproot. Flowers are white to greenish above and maroon below. There are 5 showy petals that are fused at their base and cleft at the apex. The plant appears relatively hardy, perhaps due to its ability to re-sprout from the fleshy taproot. Seeds germinate readily and seedlings are easy to establish in the greenhouse. Transplanting of seedlings to native habitats has been successful. The species occurs on a wide range of substrates and in a number of plant communities. It is found on very recent pahoehoe and a'a flows to cinder cones and areas with well developed soils. Silene occurs on barren lava, in treelands dominated by *Metrsosideros*, in mixed shrublands dominated by *Dodoneae*, *Sophora*, *Myoporum*, *Styphelia*, and in *Eragrostis* grasslands. Threats to the species are predominantly from feral animals. Sheep and goats find the above ground portion of the plant highly palatable. Wild hogs root up and consume the fleshy taproot of individuals growing in areas with better soil development.

When *Silene hawaiiensis* was listed, it was argued that it didn't warrant protection because of the large number of populations known to occur, wide distribution, protection of some populations on federal lands, and removal of pests. These arguments had some impact and the listing status was modified from endangered to threatened. Our hypothesis is that *S. hawaiiensis* is more abundant and widely distributed across the island of Hawaii than known at the time of listing. Extensive surveys into areas between existing populations have been conducted. Results indicate that numerous sympatric populations exist from the Hualalai volcano, across the saddle area in the center portion of the island to Volcanoes National Park (VNP) and on the east and west slopes of Mauna Loa. Fencing and animal control methods are being used to protect large populations from damage by feral ungulates at PTA and the VNP. Current findings support the delisting of *S. hawaiiensis*.

Endangered Species Listing Process- An Analysis of the Seed Bank of *Lepidium Papilliferum* (Slickspot Peppergrass), a Proposed Endangered Species

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Co-Authors- R.W. Lichvar, T.J. Cary, and T.L. Bashore

Mr. Antonio J. Palazzo is a Research Agronomist at the US Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory. Much of his research is focused on rehabilitation of disturbed or contaminated cold-region lands. Specific topics of research include the use of genetic markers to quantify plant traits, plant biodiversity on military installations, modeling plant root growth, breeding more adapted plant cultivars, and the revegetation of sandy, disturbed soils in cold regions. The results of his previous research have been used as guidelines for the establishment and management of vegetation on military lands. Mr. Palazzo is the past Chairman and an active member of the A-2 Division of the American Society of Agronomy.

Dr. Terry L. Bashore serves as the Senior Ecologist/Research Scientist for HQ Air Combat Command's Director of Aerospace Operations. He is the authority, scientific expert, single point of contact, and program director for all MAJCOM range and airspace activities related to natural/cultural resource management. Terry has served as a Senior Wildlife Ecologist/Operations Officer at Ft. Bliss, TX; Natural/Cultural Training Program Manager for the Army Corps of Engineers; and the Army's Natural Resources subject matter expert. He received his Ph.D in Ecology from Penn State University. Terry is Vice President of the NMFWA and a member Herp Work Group.

Counting growing individuals of an annual or biennial plant to assess long-term population dynamics without considering the seed bank may not provide an adequate assessment of a species' viability. To support the understanding of the viability and population dynamics of slickspot peppergrass (*Lepidium papilliferum* A.Nelson & Macbride), a field and greenhouse study was undertaken. Slickspot peppergrass grows primarily in slick spots in southwestern Idaho. Slick spots are small, moist, crusted or smooth-surfaced basin areas located in western United States. The slick spots sampled contained both seed-producing flowering plants and biennial rosettes. In the seed bank, viable seeds were found in the soil profile to a depth of 15 cm both within and outside the slick spots. In most locations, seeds were more abundant in the upper 5 cm of soil, and those seeds had a greater germination percentage and rate than those from lower depths. Knowledge about the viability of the seed bank allows for assessing the fluctuations in annual plant-count numbers. The plant counts from 5 years of data were strongly correlated to spring climatic conditions. These correlations help explain seasonal expansion and contraction of population numbers. This ability to assess annual population data counts provides better insight into long-term increases or decreases of population numbers and species stability.

SESSION 1B: HABITAT MODELING AND ASSESSMENT

Opening Remarks- Joan Walker, US Forest Service

Joan Walker; USPA-FS, Southern Research Station, Department of Forest Resources, Clemson University, Clemson, SC 29634; Tel: (864) 656-4822; joanwalker@fs.fed.us

Joan Walker is a research plant ecologist with the Threatened, Endangered and Sensitive Species Research Unit of the USDA Forest Service Southern Research Station. The research lab is located in the Department of Forestry and Natural Resources, Clemson University, where she serves as an adjunct faculty member and directs the research of graduate students in Forestry and Biological Sciences.

Joan conducts research needed to conserve and recover Southeastern rare plant species and their habitats. Her research focuses on the population biology of selected rare plant species of the longleaf pine savannas in the Apalachicola Lowlands, and on developing methods to restore the herbaceous layer of longleaf pine communities throughout the southeast. With collaborators and students, she has addressed research questions ranging from describing the genetic diversity and breeding systems of selected rare species to evaluating the long-term effects of plantation establishment and management on the native herbaceous vegetation. She is particularly interested in the role of fire in perpetuating rare plant species, and the use of fire in combination with other treatments to restore habitats.

Although her research lab focuses on the fire-maintained longleaf pine plant communities, they also address questions of biology and management of rare plants in other forested communities. Current projects include work on the biology of rare herbs in bottomland hardwoods, and in mid-to-high elevation cove and northern hardwood forests in the southern Appalachians.

Dr. Walker received her PhD in Biology from the University of North Carolina at Chapel Hill in 1985. After a postdoc at Duke University, she joined the Faculty at Southeastern Louisiana University where she taught Introductory Botany, Plant Systematics, and Plant Ecology. In 1988, she joined the USDA Forest Service as the first Plant Ecologist for the National Forests in Florida, and in 1990 became the first Regional Plant Ecologist for the Southern Region. In this position Walker contributed to Forest Planning efforts throughout the southeast focusing sensitive plant management and ecological land classification. In 1992, she accepted her current position with the Southern Research Station. Walker is the author or coauthor of publications on plant diversity, rare plant biology, restoration ecology, and forest management.

Modeling Animal Landscapes

Dr. Warren B. Porter; Professor of Zoology, Professor of Environmental Toxicology, U. of Wisconsin, Madison, 250 N. Mills St., Madison, WI 53706; Tel: (608) 262-1719; wpporter@wisc.edu

Co-author- Paul Bartelt

Warren B. Porter: My research centers on how do climate, disease, and environmental contaminants affect growth, reproduction, and survival at local and landscape scales? It also addresses impacts of contaminants on the nervous, endocrine, and immune systems and developmental processes.

I received my Bachelor of Science degree from the University of Wisconsin, Madison, a Master's degree in Ichthyology from UCLA. My Ph.D. is from UCLA in Physiological Ecology under Dr. Ken Norris. I did postdoctoral research in Biophysical Ecology at Washington University in St. Louis with Dr. David Gates for two years before returning to the University of Wisconsin as an Assistant Professor in Zoology. Since returning to the University of Wisconsin, Madison, I have continued to expand my technical competence by taking 37 courses in 14 different departments including Mechanical and Chemical Engineering, Atmospheric and Oceanic Sciences, Soil Science, Mathematics, Statistics, and Computer Science.

It is frequently difficult/expensive/time-consuming to obtain data on rare and endangered species to evaluate optimal habitat requirements, estimate capacity for growth and reproduction for a variety of possible scenarios of habitat management, and compute potential exposure to environmental contaminants of concern. This talk will describe first generic principles models that can address these issues quickly and at low cost. We recently published examples of tests of our landscape scale models that calculate animal energetics, potential for growth and reproduction, behavior, and habitat utilization (http://www.zoology.wisc.edu/faculty/Por/Por.html). Multiple scale climate/microclimate models, vegetation, topography, and animal properties drive these models. They have been tested in all the major groups of vertebrates and some invertebrates. The first principles mesoscale climate model utilizing global climate data provides users selected resolution of climate in space and time. The climate model provides data for high space/time resolution microclimate calculations and animal energetics on PCs. The integrated climate/animal models can calculate daily exposure to environmental contaminants and pathogens in air, food, and water. Input data for animal morphological properties can be obtained from museum specimens and photographs. Estimates of physiological and behavioral properties are typically available from the open literature or may be measured if necessary. Remote sensing (satellite imagery) can be used as both input and tests for microclimate calculations and most likely habitat utilization choices. Examples of subtle vegetation changes that affect Bachman’s sparrow at Cherry Point Marine Station, Yellowstone amphibian habitat utilization and Southern California predator-prey (snake-mammal) interactions will be described.

Identifying Habitats of Rare Species On and Around Military Installations

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Co-Author- Latha Baskaran

Dr. Virginia Dale is an ecologist whose research focuses on developing tools for resource management, ecological indicators, and vegetation recovery subsequent to disturbances. She is a Corporate Fellow in the Environmental Sciences Division at Oak Ridge National Laboratory, where she has been since 1984. She obtained her Ph.D. in mathematical ecology from the University of Washington.

Dr. Dale has published over 150 scientific articles, edited five books, and is a co-author of the recent book Road Ecology: Science and Solutions. She has served on scientific advisory boards of four federal agencies and is on several committees of the National Academy of Sciences. She is Editor-in-Chief of the journal Environmental Management and is on the editorial board for two journals: Ecological Indicators and Ecological Economics. She and her husband have raised their three children in Oak Ridge, Tennessee.

In order to manage rare species, it is critical to identify their potential habitats. Using spatial data and geographic information systems, we developed models that can project potential habitat for Karner blue butterfly (*Lycaedides melissa samuelis*) at Fort McCoy in Wisconsin, threatened calcareous ecosystems that support limestone-endemic plants at Fort Knox in Kentucky, and gopher tortoise (*Gopherus polyphemus*) at Fort Benning in Georgia. Because military lands often harbor large populations of rare species, these models are useful for ecological management inside the installations. A challenge resource managers face is relating onsite training, testing, and management activities to land-use practices beyond the installation boundaries. Therefore, we created a model of gopher tortoise habitat based on analysis of documented locations of gopher tortoise burrows at Fort Benning and used it to generate a probability map for the occurrence of burrows in the five-county region surrounding Fort Benning. Accuracy of the model was tested based on ground visits that were made to test model predicted habitats. The results show that information on land cover, soils, and distances to streams and roads can be used to predict locations of gopher tortoise burrows. This approach can be used to better understand and effectively carry out gopher tortoise habitat restoration and preservation activities. These tests and results facilitate the ability of military planners and resource managers to operate and plan with a better understanding of risks to habitats of rare species.

Evaluation of Faunal Species of Concern-A Quantitative Approach

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Co-Authors- Dwayne A. Hightower, and Ken Dancak

Dr. Wagner is a quantitative ecologist interested in the estimation of biological population parameters in space and time. He has over 12 years of experience as a natural resources consultant and analyst and is currently a principal with Quantitative Ecological Services, Inc. His work has been focused on developing tools to assist federal and state agencies to resolve complex and sensitive environmental and natural resource management issues. He is particularly interested in estimating animal-habit relationships, especially at landscape scales.

Military installations and other federal agencies must evaluate potential impacts of proposed actions and natural resource management strategies on species of concern, which may include threatened and endangered species, US Fish and Wildlife Service Birds of Conservation Concern, Migratory Bird Treaty Act species, and State/Agency sensitive and conservation species. Often, evaluation of faunal species of concern is limited to qualitative inference based on generic species accounts, which may have little applicability to the project area, or on detailed micro habitat evaluations that are difficult to extrapolate to the large spatial scales typically required in such evaluations. We present a quantitative approach to estimate the impacts of proposed actions and management strategies that alter the composition and quantity of habitat available to faunal species of concern. Our approach can be applied where landscape scale habitat data (e.g., forest stands data) and species survey data (e.g., avian point counts) are available. Our approach consists of first identifying species of concern likely to occur in the project area, and then estimating species' relative habitat use by calculating resource selection functions (RSF), a likelihood-based use-versus-availability analysis. RSFs are calculated using landscape scale habitat data and species survey data. The extent of habitat changes from pre- to post-project is quantified, and the risk to each species associated with the projected habitat changes is estimated. We present an example of the application of this approach using a mock project and actual species survey and habitat data.

LIDAR and Multispectral Imagery for Avian TES Habitat Assessment

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Co-Authors- Dr. Raquel Leyva, Ms. Lee Graham, and Dr. John H. Hill

Mr. Tweddale is a research geographer with the US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL). His research has been focused on the application of geospatial technologies for military natural resource and land management, with an emphasis on development of image processing and GIS analysis techniques as they apply to quantification of ecological parameters. Mr. Tweddale has a B.S. and M.S. in geography from the U. of Illinois.

Light Detection and Ranging (LIDAR) and multispectral imagery have been used to characterize vegetation structure and composition in areas of potential habitat for the federally listed, endangered black-capped vireo (BCV) (*Vireo atricapillus*) and golden-cheeked warbler (GCWA) (*Dendroica chrysoparia*) at Fort Hood, TX, and the red-cockaded woodpecker (RCW) (*Picoides borealis*) at Ft. Bragg, NC. Metrics derived from remotely-sensed imagery that quantify vertical structure of vegetation have been difficult to incorporate into Threatened and Endangered Species (TES) habitat characterization protocols due to limited capabilities for sensing sub-canopy, mid-story, and under-story habitat characteristics. LIDAR now provides the capability to remotely sense such characteristics.

Vertical distribution of vegetation between 0-3m is critical for determining habitat suitability for BCV, and upper canopy structure is critical for determining suitability for GCWA. Similarly, the height and density of understory vegetation is critical for determining habitat suitability for RCW. A combination of LIDAR and multispectral imagery has been analyzed to assess these habitat characteristics and has been combined with ancillary geospatial data to assess habitat potential in otherwise inaccessible areas (e.g. impact areas, adjoining private lands). The techniques and protocols for analyzing LIDAR that have been developed are also adaptable to assessment of other TES habitats and other applications that require an assessment of the vertical distribution and structure of vegetation.

Black-capped vireo: Raquel Leyva[2], Lee Graham[3 and 4], and John M. Hill[4]
Golden-cheeked warbler: Raquel Leyva[2] and Verl Emrick[5]
Red-cockaded woodpecker: David Evans[6], Scott Roberts[6], Peter Campbell[7]
[1] US Army Corps of Engineers – ERDC -CERL. [2] The Nature Conservancy of Texas.
[3] Michael Baker Corporation. [4] USGS - National Biological Information Infrastructure (NBII). [5] Virginia Tech U. – Conservation Management Institute. [6] Mississippi St. U.
[7] US Fish and Wildlife Service

Biodiversity of Threatened and Endangered Species on Army Training Lands

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Co-Authors-Reiner Büttner, Debra A. Dale, Nathaniel L. Whelan and Scott W. Holbrook

Dr. Warren has been involved in research related to military training lands for 20 years. He spent 13 years as a research ecologist with the US Army Construction Engineering Research Laboratory in Champaign, Illinois where he was instrumental in the development of various aspects of the Army's Integrated Training Area Management (ITAM) program. For the past 7 years he has served as an Associate Director and Senior Research Scientist at the Center for Environmental Management of Military Lands at Colorado State University. He has worked on military training lands throughout the United States and Germany.

Military training lands are typically characterized by a high density of threatened and endangered species, and high overall biodiversity. In the United States, the density of threatened and endangered species is 3 to 18 times greater on Department of Defense lands than on lands managed by other Federal agencies. In German state of Bavaria, the Grafenwöhr and Hohenfels Training Areas support 2 to 3 times more threatened and endangered species per unit area than national forests, national parks, and other designated nature protection areas. We propose a 'heterogeneous disturbance hypothesis' to explain the phenomenon. On any given training area, the mosaic of disturbance levels typically ranges from badly disturbed to nearly pristine. We suggest that military disturbances replace, in part, natural disturbances that have been eliminated or reduced by well-intentioned land managers and public policy on non-military lands. Furthermore, the disturbances that occur on Army training lands are generally heterogeneous in time, space, and intensity, compared to more homogenous human-induced disturbances occurring elsewhere. The heterogeneous nature of the disturbance creates a habitat mosaic capable of sustaining a greater number of species, many of which are disturbance-dependent. Eight threatened and endangered species (two amphibians, 2 insects and 4 plants) were investigated on US Army training areas in Germany to examine their dependence on disturbance. All eight species showed some degree of disturbance-dependence, ranging from preference for near 100% recent surface disturbance to preference for disturbance $\geq$ 5 years old. The habitat mosaic created by the spatially and temporally heterogeneous distribution of military training impacts has created nearly ideal conditions for those species that depend on intensive recent disturbance, those that avoid disturbed areas altogether, and all species in between.

Individual Tree Crown Delineation; Tracking RCW Habitat One Tree at a Time

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Mr. Tombs is a Senior GIS Manager with Shaw Environmental and Infrastructure, Inc and manages the company's Northern California GIS and Remote Sensing Group. Mr. Tombs' consulting experience focuses on web-based Geographic Information Systems (GIS) solutions, Remote Sensing, Environmental Remediation, and Database Administration. Mr. Tombs is a Canadian citizen and has his Master of Natural Resources Management degree from the University of Manitoba with a focus on GIS, Radar Decision Support Systems (RDSS) and environmental management.

Using state of the art remote sensing and image classification techniques, the United States military can now track and monitor every facility tree as an individual asset in a GIS database. This can allow for the management of endangered species habitat on a tree to tree basis while concurrently managing merchantable timber volumes. This technique is currently being implemented at Avon Park Air Force Range.

Avon Park AFR, encompassing 182 sq. miles, has approximately 40,000 acres of Red Cockaded Woodpecker (RCW) Habitat. With an ongoing forestry program tasked with the harvest of merchantable timber, combined with an RCW habitat management program, the facility was in need of a more robust RCW habitat tracking application.

It was determined that with a combination of remote sensing, image classification and geographic information systems (GIS), the facility could track and manage the RCW habitat on a tree to tree basis.

Shaw is currently designing and implementing this habitat tracking application. The first step in the process is the acquisition of high resolution satellite imagery. 2.4-meter multispectral imagery, sharpened with 60-centimeter panchromatic data is used as it contains the information required to determine species type and crown size.

Once the images are captured and the quality control approved, the Remote Sensing specialist will define field training sites. Generally, 20 sites are needed for each species of interest with fewer training sites required for species of lesser interest. In addition, collateral information such as recent aerial photography and facility expertise is used to better orient training site locations. This step is a very important one, because the classification results will depend on the quality and the precision of the available information.

With the information provided by the field training sites, the remote sensing specialist will build the spectral signatures of each species. The Individual Tree Crown (ITC) classification is done over each satellite scene individually. A preliminary ITC classification is processed and the resulting map is validated in the field based on a predetermined validation protocol.

The final step is the ITC crown Delineation & ITC Attributes Generation. The Shaw team will then build the ITC Forest Stand and tree crown (vector format) consisting of polygons attached to a spatial database. Once complete, facility personnel will have a robust GIS tool available for managing and querying merchantable timber and RCW habitat.

The Use of GIS & Decision Support for the Conservation & Management of an Endangered Species: Translocation of the Desert Tortoise form Military Land

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Dr. Leuteritz is a conservation ecologist and the senior scientist for the Redlands Institute, University of Redlands, Redlands, CA. He completed his doctorate in Environmental Science and Public Policy at George Mason University. Thomas has worked internationally on tortoise conservation and biodiversity issues in Senegal, Madagascar, and South Africa. He has also assisted in running an international project for Conservation International at the Center for Applied Biodiversity Science in Washington, D.C. Currently he assists with the management and direction of the Desert Tortoise Project in the Mojave.

In 2000 Congress approved the expansion of the National Training Center (NTC) at Ft Irwin. The expansion area covers a total area of 133,000 acres (22,000 acres of Fort Irwin, 46,438 acres east in Silurian Valley, and 63,673 acres west in Superior Valley). This area is also prime desert tortoise (*Gopherus agassizii*) habitat. As a means to protect tortoises and to better understand their biology, the Army has agreed to translocate the affected animals. This will be a major undertaking because it is estimated that at least 1000 tortoises will have to be moved. Here we outline how GIS and decision support was used as a conservation tool to allow managers and policy makers to decide on where to translocate tortoises. Our goals were to do this 1) using the "best available data" and 2) in a scientific and objective manner. This therefore included considering parameters such as habitat suitability, genetics, historical tortoise abundance, threats, landownership, land use, and projected urban growth. The model covered a 7946 sq. mi. core area within the West Mojave Desert Management Planning area. This core area was defined to include areas proximate to NTC, the West Mojave DWMAs (Desert Wildlife Management Areas), and because it contained most of the available data from tortoise surveys. Recipient sites were identified using a spatial decision support system (customized ArcGIS geoprocessing models in combination with Ecosystem Management Decision Support). One of the benefits of this type of system is its ability to run 'what-if' scenarios that permit investigation of the relative costs and benefits of a variety of potential management actions.

Comparison of Threatened & Endangered Resource Issues on Tropical Pacific Ranges

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David A. Helweg is Deputy Director of the Pacific Island Ecosystems Research Center of the US Geological Survey. The mandate of this USGS biology research center extends from Hawaii across the islands, atolls, and near-shore ecosystems of Oceania. He received his Ph.D. from the University of Hawaii in 1993, his M.A. from the University of Hawaii in 1989, and his B.A. from Amherst College in 1981. Dr. Helweg has studied comparative socioecology and bioacoustics in marine mammals, and has introduced several new methods for analysis and automated classification of animal vocalizations. He has over 40 publications in the domains of animal biosonar, bioacoustics, and behavioral biology, and is a member of the Acoustical Society of America and the American Institute of Biological Sciences.

The Department of Defense operates numerous ranges in Hawaii and the tropical Pacific. Management of those ranges is complex, requiring balance between ability to maintain warfighting readiness and stewardship of species of concern. Species of concern, some listed as threatened or endangered under the ESA, are found in marine and terrestrial ecosystems. Some T/E species are resident and others seasonal migratory visitors. Because of the diversity of ecosystems and sociocultural factors across the region, it seems likely that no single resource management methodology could be adopted universally. We will compare terrestrial and marine natural resource management issues for selected sites in Hawaii and the western Pacific, and show how different resource management programs are evolving to support range sustainability.

SESSION 2A: INVASIVE SPECIES: RED IMPORTED FIRE-ANTS

Opening Remarks- Dr. Daniel Friese, Air Force Center for Environmental Excellence (AFCEE)

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Protection of Nesting Black-Capped Vireos from Red Imported Fire Ant Depredation at Fort Hood, TX

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*Mr. Pekins got his B.S. in Ecology, Evolution, and Conservation Biology with a minor in Chemistry at The University of Texas at Austin, December 2000. He served as an Army soldier 1989-1995. Telecommunications combat support at Darmstadt, Germany (V Corps); Fort Polk, LA (5th Mechanized Infantry); and Fort Hood, TX (2nd Armored Division). Field Biologist, 1999-2001, The Nature Conservancy of Texas, Fort Hood Field Office. Black-capped vireo (*Vireo atricapilla*) and golden-cheeked warbler (*Dendroica chrysoparia*) demography studies, habitat studies, and nest depredation studies using infra-red video cameras. Wildlife Biologist (Endangered Species), 2001- current, Fort Hood Natural Resources Management Branch. Conduct and assist with biological inventories of flora and fauna, wildlife surveys, endangered species surveys, karst studies and karst biota management, assist with research coordination, serve as liaison for contractors/researchers, and assist the US Army, III Corps with Endangered Species Act compliance. I am an amateur naturalist who seeks to understand all components that constitute an ecosystem. My interests include natural history, human landscape use, and human impacts on the earth. My hobbies include weather, gardening, and Volkswagen Beetles.*

Fort Hood is an 88,000 ha Army installation located in central Texas. Military training on the installation includes heavy armor and artillery live fire maneuvers with rotary-wing and combat service support. Federally endangered black-capped vireos (BCV) nest on Fort Hood, which has the largest population of the species under a single management authority. Based on a 5-year IR camera study, red imported fire ants (RIF) are one of the major predators of vireo nests on the installation. Additionally, RIF (an invasive, aggressive, non-native species) are ubiquitous in vireo habitat. Moderate levels of military training help maintain vireo habitat; however, training contributes to RIF spread via mechanical land disturbance and wild land fire. Protection from RIF during the vireo nesting cycle will decrease depredation by RIF and will lead to increased vireo reproductive output and recruitment into the local population. Chemically, RIF have been controlled by broadcast baits and broad application of liquid and dust insecticides. These applications are not feasible on Fort Hood due to our karst landscape. Karst terrain has special landforms with shallow soil horizons and drainage characteristics which funnel water rapidly through canyons and underground to springs via karst features (caves, sinkholes, and rock fractures). Highly specialized and highly evolved cave biota live in these karst features. Chemists at BioGuard and USDA designed sustained release repellant devices which can be applied at localized micro-levels, provide a small vapor barrier, leave no residue, and resist transport underground. Ground distributed sustained release devices which we tested evolved through a lineage from fairly non-porous, polyurethane 1-cm^2 cubes, then to highly porous, polyethylene/polypropylene (MP) 3-mm pellets, and to moderately porous, clay/wood fiber granules. The latter are designed to degrade with moisture and provide both a surface and a shallow (5 to 10-cm) subterranean protective zone. We also tested polyurethane 4-cm^2 stem clamps which we attach 10 to15-cm away from the vireo nest. The ground distributed and the stem clamp devices were loaded with repellants (non-insecticidal and low concentration insecticide). The devices emit a 5-cm vapor zone and are volatile for 115-180 days, long enough for protection during the 28-day vireo nesting cycle. The MP pellets and the clay/wood fiber granules will degrade *in situ*. In 2003 and 2004, the devices were deployed around and near BCV nests. Because RIF do not discriminate which species they depredate, we also tested the devices on white-eyed vireos and painted buntings; both species nest in the same habitat and have very similar nests as BCV. Sixty-two nests with the devices were studied, 31 were control (no repellant in the device) and 31 were treatment (repellant in the device). Pellets and stem clamps significantly reduced depredation by fire ants on vireo nests (X^2= 4.455, df= 1. N= 11, P= .037). In 2005, we are continuing the study using the same concept, but with a newly designed ground distributed clay/wood fiber granule. The application of the devices may be useful for managers seeking to reverse declining bird populations, or managing critically depleted populations of sensitive species where risk of local extinction is high.

Hot Water Treatment for Red Imported Fire Ants (*Solenopsis Invicta*)

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Co-Authors- Andy Gluesenkamp, Jean Krejca, and Peter Sprouse

Rob Myers received a B.S. in Biology from the University of Texas in 2003. After graduating, he worked for UT Austin monitoring bird populations at Camp Swift and Camp Mabry. He was then employed by Jones Technologies as part of a team studying the effects of disturbance on endangered Black Capped Vireos at Ft. Hood. He now works as an ornithologist and karst biologist for Zara Environmental LLC.

Solenopsis invicta, the red imported fire ant, was first introduced to the United States from South America in the 1930's. They now infest over 260 million acres in nine states across the southeast and are projected to expand their range from Florida to California and up the West coast to Washington. Fire ants are a nuisance due to their fierce nature, painful sting, and ability to damage electrical equipment and make areas unsuitable for human use. In North America they also threaten native biota as they decimate arthropod communities and attack young birds and mammals that cannot escape them. In some areas, including our study sites in Central Texas, the threat is exacerbated by a multiple queen (*polygyne*) form that shows increased mound densities of 200 mounds per acre.

On Camp Bullis, TX, controlling fire ants became a management priority in 1999 because of the threat they pose to several species of federally listed, endemic cave arthropods. Subterranean ecosystems are often nutrient poor when compared to surface ecosystems and any factors that alter nutrient flow into caves could have widespread effects on cave communities. One major nutrient input for caves comes from omnivorous cave crickets, *Ceuthophilus secretus*, which exit caves at night to forage. Crickets convey nutrients gathered on the surface into caves when they return to the caves and defecate, oviposit, or die. Crickets are especially important to the conservation of two federally listed beetles, *Rhadine exilis* and *R. infernalis*, because they are dietary specialists that feed on cave cricket eggs deposited in caves. The importance of cave crickets to endangered cave invertebrates necessitates efforts that minimize competition for food resources between crickets and fire ants.

We have incorporated recent findings on fire ant ecology and *C. secretus* foraging behaviors in developing a treatment methodology that effectively reduces fire ant infestations in the critical areas surrounding cave entrances. This methodology is in use at Camp Bullis, Texas where we are monitoring mound densities and eradicating fire ant mounds with hot water around 74 caves. The method is easy to duplicate, requires basic tools, does not required the use of pesticides, and can be applied to any ecologically sensitive area, as well as parks, playgrounds, and suburban yards.

Management Concerns for Cave Ecosystems in Central Texas

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Jean received her B.S. in Zoology at Southern Illinois University and her Ph.D. in Ecology, Evolution and Behavior at the University of Texas. She has worked extensively with the Illinois Natural History Survey and also for the United States Fish and Wildlife Service Austin Ecological Services office.

Her specialty is working with cave management, cave biology and karst hydrogeology. She co-founded and is the president of Zara Environmental LLC, an environmental consulting company with expertise in species and habitat management and endangered species issues. Zara Environmental performs work in various states in the US and Mexico.

Fort Hood, Texas has over two hundred documented cave and karst features which contain endemic arthropods and an undescribed species of Plethodon salamander. Management concerns for these organisms center around land use and the introduced red imported fire ant, *Solenopsis invicta*. To address the issue of land use buffers, we asked the question: How far from entrances do cave crickets, a keystone species in the cave community, forage at night? Using UV fluorescent paint, foraging distances were found to be up to 105 m (the maximum area searched) with fairly uniform densities out to 80 m from cave entrances. A follow-up study using radio transmitters revealed differences in foraging by sex and also showed movement between caves. Another question asked was: To what extent do fire ants forage in caves? Baiting, as well as quadrat counts showed that in-cave foraging by fire ants was much less than on the surface and primarily in the shallow entrance areas (<18m distance, <7m depth). In our sample of six caves, presence of fire ants in caves was negatively related to species richness, but not significantly ($p=0.075$). Fire ants were dominant (>2%) in 3/6 sites, and their presence in caves had seasonal and microclimatic patterns. A final question currently being addressed is: Are there patterns between fire ant and Plethodon sp. distribution or population size? An initial study showed no significant relationship between distribution of fire ants and Plethodon, and ongoing work is documenting population size at two localities.

SESSION 2B: INVENTORY AND MONITORING (PART 1)

Opening Remarks- Paul Dresler, US Geological Survey

Paul Dresler; Program Coordinator, Status and Trends of Biological Resources, USG.S., MS 301, 12201 Sunrise Valley Drive, Reston, VA 20192; Tel: (703) 648-4114; paul_dresler@usgs.gov

Paul Dresler is the Coordinator for the US Geological Survey's Status and Trends of Biological Resources Program. The Program is a $21 M effort that works closely with partner organizations to design, collect and analyze the abundance, distribution, and trends of biological resources ranging from microbes to mammals. Examples of monitoring activities incorporated within the Program are the:

- *Breeding Bird Survey of North America – A joint effort with the Canadian Wildlife Service that provides annual trend data on over 420 species of migratory birds spanning the US and southern Canada;*
- *Bird Banding Laboratory – A joint effort with the Canadians to provide high-quality banding data for use in developing effective bird conservation and management strategies throughout North America. The data base contains over 60 million records with roughly 1.3 million new entries each year;*
- *Great Lakes Fish Stock Assessments – A long-term assessment of forage fish stocks conducted within the deep offshore waters of Great Lakes. The information is used to by an international commission to set fish harvests; and*
- *Numerous projects at national, regional and local scales to address the biological monitoring needs of the resource management and conservation communities.*

Prior to becoming the coordinator of this Program Paul served over eight years as a senior science and policy advisor to the Assistant Secretary for Water and Science at the Department of the Interior. Paul's career with USGS has spanned over 27 years where he began as a biologist studying benthic invertebrate communities in tidal rivers and estuaries. He has a Bachelors and Masters degree in Biology from the University of Maryland.

Developing Information Systems for Species Monitoring Programs

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Co-Authors- Robert O. Wagner, and Stephanie Stephens

Mr. Hightower has worked for over four years as an ecologist for Quantitative Ecological Services Inc. (QES) assisting federal agencies, including the US Army and US Forest Service, with the development of data management systems and the statistical analysis of environmental and biological data. He spent three years prior to his employment with QES as a Research Associate for Louisiana State University, School of Forestry, Wildlife, and Fisheries supervising field operations and serving as data manager for the Louisiana Black Bear Project, a research project to gather scientific information for the recovery of this threatened species.

Military installations have been largely protected from development, whereas many surrounding areas have been subject to increasing urbanization, particularly those in the southeastern US As a result, military installations have become refugia for numerous threatened and endangered species (TES). Under the Endangered Species Act of 1973, these species must be managed for on Federal lands and considered in land use planning. To fulfill these obligations, adequate information must be obtained on the distribution and status of TES, and the conditions of the resources on which they depend. Those data are typically gathered through a monitoring program. To be effective, monitoring programs must be designed to address specific goals. Those goals define the information that must be produced, which in turn defines the data elements to be collected. Once the required elements are identified, then an information system consisting of data collection protocols, standardized field data capture tools, a data storage device, and information development processes can be produced. As an example, we present the development process of an information system for the capture, storage, analysis, and multi-level reporting of red-cockaded woodpecker (RCW; *Picoides borealis*) monitoring data for the Joint Readiness Training Center (JRTC) and Fort Polk training lands in Louisiana. We also demonstrate how the system has improved management of the RCW population occupying training lands, as well as the installation's ability to address issues that could have impacted its mission.

Monitoring of Threatened and Endangered Species Through Inferential Monitoring

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Monitoring of biological resources is important because it allows for a better understanding of ecological systems and allows for an educated assessment of the target population using theoretic approaches such as adaptive management. Typically, the purpose of monitoring is to obtain estimates of parameters like abundance or density at specific time intervals to track changes in the target population. This information is essential for the recovery of Threatened & Endangered (T&E) species because it provides biological data that tracks the process that ideally leads to delisting. When selecting variables to monitor, managers first need to carefully consider their objectives, the geographic and temporal scale at which they will operate, and the effort needed to implement the program. Generally, monitoring programs can be divided into two categories: index and inferential. Although index monitoring is usually easier to implement, analysis of index data requires strong assumptions about consistency in detection rates over time and space, and parameters are often biased because they do not account for detectability and spatial variation. In most cases, individuals are not always available for detection during sampling periods, and the entire area of interest cannot be sampled. Conversely, inferential monitoring is more rigorous because it is based on nearly unbiased estimators of spatial distribution. Repeated surveys during the field season and assigning sites randomly across the study area can account for both sources of variability. An added benefit is the opportunity to discriminate among competing hypotheses. Thus, we recommend that detectability and spatial variation be considered for all monitoring programs that intend to make inferences about the target population or area of interest. Application of these techniques is especially important for monitoring of T&E species (and related threats) because it is critical to determine if population size is increasing or decreasing with some level of certainty. Although inferential monitoring requires more time and effort to implement than indexes, use of these estimation-based methods and probability sampling will reduce many of the biases inherently associated with index data and provide meaningful information with respect to changes that occur in target populations. We incorporated inferential monitoring into protocols for T&E species spanning a wide range of taxa on the Cherokee National Forest in the Southern Appalachian Mountains. We review the various approaches employed for different taxa and discuss design issues, sampling strategies, data analysis, and the details of estimating detectability using site occupancy. These techniques provide a science-based approach for monitoring and can be of value to all agencies responsible for the management of T&E species.

Evaluation of Distance Sampling for Estimating the Abundance of the Black-Capped Vireo on Fort Hood, Texas

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Fort Hood, an 88,000-ha army training facility hosts a large breeding population of the endangered black-capped vireo (*Vireo atricapilla*). In order to evaluate progress toward management goals for the species on the installation, it is important to estimate the number of birds present. We evaluated distance sampling as a technique for vireo estimating the abundance. Three field biologists conducted 250 6-min point transect surveys from 12 April to 2 June within 350 ha of shrubland habitat. Within the same area, 8 field biologists determined the number of males present by means of an intensive program of color-banding and territory mapping. These workers determined that 201 male vireos were present. We considered this estimate to represent the true number of birds present and used it to evaluate the accuracy of the distance sampling estimates. After fitting a hazard rate model to the 6-minute point transect data, we determined that the 95% confidence interval for the number of male vireos present was 292–476. The confidence intervals based on 5 and 3-minute counts were 231–399 and 182–333, respectively. We conclude that distance sampling provided accurate estimates of the number of male black-capped vireos only when surveys were limited to 3 min. Longer counts likely result in overestimates because black-capped vireos are relatively active birds that move constantly. We also tested the assumption that distances were measured accurately. Meeting this assumption is important at shorter distances, but may prove difficult in the dense, shrubby vegetation where the vireos are found. Accurate measurement was most critical for modeling the detection function for distances within 25 m of the observer. We found that 86% of distance measurements within this zone could be made directly with a laser rangefinder. We conclude that distances could be measured with reasonable accuracy.

Use of Thermal Infrared Videography for Study of Warm-Blooded TES Species

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Mr. Sabol is a research engineer with the US Army Engineer Research and Development Center in Vicksburg, MS. His educational background includes degrees in environmental engineering and in biology. He is a registered professional engineer in the state of Mississippi. Mr. Sabol's current research focus is in development, testing, and simulation of sensors for environmental and military applications.

The use of thermal infrared imaging systems has proven to be a valuable tool for non-invasive detection and monitoring of wildlife at stand-off distances. The remote detection capability can be particularly important on military lands when monitoring active firing ranges and areas containing UXO. The literature contains numerous examples of detecting warm-blooded wildlife species using airborne and ground-based thermal imaging systems. Most of these cases employ human interpreters that detect and count individuals using subjective visual-based techniques. We describe an emerging technique used to detect and census bats and birds in flight that employs digital image processing of thermal infrared video imagery. Thermal infrared video imagery, sometimes transmitted via microwave from within active firing ranges, was digitally recorded. A digital image processing software system was developed to automatically detect, track, and count warm-blooded “targets” in flight. The basics of this processing technique and its applications are described and data are presented for censusing various bat species, including large emergences of endangered gray bats (*Myotis grisescens*). Potential adaptability of the technique to other warm-blooded T&E species is described.

SESSION 3B: INVENTORY AND MONITORING (PART 2)

Opening Remarks- Paul Dresler, US Geological Survey

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Paul Dresler is the Coordinator for the US Geological Survey's Status and Trends of Biological Resources Program. The Program is a $21 M effort that works closely with partner organizations to design, collect and analyze the abundance, distribution, and trends of biological resources ranging from microbes to mammals. Examples of monitoring activities incorporated within the Program are the:

- *Breeding Bird Survey of North America – A joint effort with the Canadian Wildlife Service that provides annual trend data on over 420 species of migratory birds spanning the US and southern Canada;*
- *Bird Banding Laboratory – A joint effort with the Canadians to provide high-quality banding data for use in developing effective bird conservation and management strategies throughout North America. The data base contains over 60 million records with roughly 1.3 million new entries each year;*
- *Great Lakes Fish Stock Assessments – A long-term assessment of forage fish stocks conducted within the deep offshore waters of Great Lakes. The information is used to by an international commission to set fish harvests; and*
- *Numerous projects at national, regional and local scales to address the biological monitoring needs of the resource management and conservation communities.*

Prior to becoming the coordinator of this Program Paul served over eight years as a senior science and policy advisor to the Assistant Secretary for Water and Science at the Department of the Interior. Paul's career with USGS has spanned over 27 years where he began as a biologist studying benthic invertebrate communities in tidal rivers and estuaries. He has a Bachelors and Masters degree in Biology from the University of Maryland.

The Indiana Bat on Newport Chemical Depot, Vermillion County: A Fragmented Landscape

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Virgil Brack Jr. received a B.S. from the University of Missouri-Columbia in Forestry, Fisheries, and Wildlife and M.A in Biology from the University of Missouri-Columbia. His thesis was on the hibernation of bats. His Ph.D. dissertation, completed at Purdue University, was on the summer ecology of the Indiana bat. He has been active in research on regulatory and ecological aspects of endangered bats for 25 years. He completed an MBA at Xavier University.

Netting for bats was completed in 1987, 1994, 1997, 1998, and 2003 on Newport Chemical Depot, Vermillion County, Indiana. Reproductive females and juveniles were radio tagged and tracked to diurnal roosts in 1997 and 2003. Indiana bats used several roosts within the same general area, supporting the hypothesis of a fission-fusion social system. Roosts with large numbers of individuals may be advantageous when thermoregulatory demands are high, while roosts with fewer individuals may reduce parasitism and locate individuals closer to foraging areas. Roosts and capture sites were scattered across a landscape that is heavily developed for agriculture and other uses. Areas used by Indiana bats, including roost sites, were often in small isolated woodlots, requiring that bats cross large open areas, roads, and areas of various types of land use. One roost was on the edge of a 0.7 ha woodlot, adjacent to a 4-lane divided highway. Management practices such as tree girdling for timber stand improvement likely benefited the species. The Indiana bat is clearly capable of using a fragmented landscape provided there are suitable roost trees and foraging habitat. Pre-settlement habitat in the core range of this species was a mosaic of open and wooded lands. Conservation of small or isolated wooded tracts may provide incremental benefits to the species, which may be particularly important in areas where woodlands are scarce.

Innovative Techniques for Monitoring Indiana Bat (Myotis sodalist) Maternity Populations

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Research Interests: threatened and endangered species population, monitoring; threatened and endangered species habitat characterization; invasive species biology and management, and applications of geostatistical methods in ecology. Education: BS, Zoology, Michigan State University MS, Biology, Ohio University
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The federally endangered Indiana bat (*Myotis sodalis*) has been documented on eight Army installations and potentially occurs on many others. Although listed as an endangered species since 1967, counts taken at winter hibernacula suggest the number of Indiana bats has continually declined during most of the past 37 years. However, counts taken at hibernacula only provide a regional or range-wide perspective on abundance and population trends. Unfortunately, local changes in Indiana bat populations on Army and other Federal properties are not well understood because basic measurement of Indiana bat presence, abundance, demography, population dynamics, and habitat use in the species' summer maternity range remains highly problematic. Attempts to measure these important factors are typically constrained by the use of methods that are expensive to implement, provide limited or inconclusive information, and/or have an unknown level of accuracy. Because there currently is no effective method of accurately estimating the size of local Indiana bat populations or monitoring for trends, installations are often in a position of needing to make management decisions without useful information.

The US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL), in collaboration with Camp Atterbury, Southern Illinois University, Portland State University, and Western Michigan University, is currently developing and testing an innovative approach for monitoring local Indiana bat populations within the species' maternity range. Our approach includes the development and integration of novel technologies such as man-made roosting structures, fecal genetic identification, infrared detection, and radio frequency identification. Automated infrared detectors are being integrated with man-made roosts (e.g., rocket style bat boxes and fiberglass Bat Barks) to allow accurate concurrent counts of bats at maternity roosts. Genetic analysis of scat collected at the base of roosts using the species-specific PCR probes and DNA microarray we developed, allows us to non-invasively identify which species are occupying roosts, and estimate the species' proportional composition. We are then able to calculate how many of the bats counted at roosts are Indiana bats. Using radio frequency identification (e.g., PIT tags) of individually marked bats we are also able to non-invasively re-sight bats at roosts. Mark-recapture analyses of these data will provide heretofore unavailable estimates of local population size, population growth rate, and survival rates for Indiana bat. With accurate estimates of Indiana bat population size Camp Atterbury will be able to initiate a long-term population monitoring program. Products of this research effort will include new basic information about Indiana bat roost use, DNA microarray technology that can differentiate 38 bat species from fecal pellets, designs for developing robust monitoring programs, and new standardized methodologies for estimating local Indiana bat population abundance, demographics and viability. The information provided by our approach will also allow Army installations and other Federal land managers to more effectively plan and evaluate Indiana bat-related management actions.

Minimizing Uncertainty in Presence/Absence Classification of Rare Salamander Populations

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Dr. Mark Bevelhimer is an aquatic ecologist with the Environmental Sciences Division of Oak Ridge National Laboratory where he has studied the effects of various environmental stressors on the management and conservation of aquatic organisms for the past 15 years. He received a B.A. degree from Wabash College (Indiana), an M.S. from Ohio State University, and a Ph.D. from The University of Tennessee.

Because they are rare, T&E species by nature are usually hard to sample. Repeated sampling of a habitat without successfully finding an individual is not necessarily confirmation that the rare species is not a part-time or full-time resident of a particular area or habitat. Reducing the uncertainty surrounding the presence of rare species on military installations is crucial to 1) effective species conservation and habitat protection and 2) minimizing unnecessary restrictions on military activities.

The flatwoods salamander (*Ambystoma cingulatum*) is a cryptic species that has been found in 25 ephemeral ponds on the Fort Stewart (Georgia) army base and could potentially exist in several hundred more. Accurately characterizing the presence/absence of this species in the 400+ ponds that might contain them is a daunting task. We are in the midst of a project that combines intensive systematic field sampling, habitat modeling, and probability statistics to predict the likelihood of collecting *A. cingulatum* in individual ponds during annual sampling. The methods we develop during this study will be used to more efficiently sample Fort Stewart ponds of unknown *A. cingulatum* occurrence and to establish measures of confidence on presence/absence characterization.

We will be using habitat niche modeling to predict the likelihood of *A. cingulatum* presence and results from field sampling to predict the likelihood of capture if present. During field sampling during Feb-May 2005, we compared the effectiveness of various methods for capturing larval *A. cingulatum* and other amphibians. Preliminary analysis suggests that dipnetting is more effective than various passive traps we employed. Our thorough sampling resulted in the first larval *A. cingulatum* collection in Fort Stewart flatwoods ponds since 1999. Collection of 29 larval *A. cingulatum* this year occurred a few weeks beyond the period of normal larval residence and was likely a result of a dry winter and later than normal pond inundation. These results suggest that the period of potential residence is longer than previously thought and have significant ramifications to future sample design. We discuss the connection between late winter rain events, the timing of larval appearance, and the potential for missed collection in previous years.

For the statistical modeling we will consider a multitude of factors that relate to the likelihood of *A. cingulatum* presence and possible capture. This information will be used to develop sampling schemes that will provide a level of statistical confidence to a conclusion that *A. cingulatum* does not exist if not found in repeated sampling. This general approach of sampling and habitat modeling should provide a standardized and statistically defensible method for adequately determining the presence of many threatened and endangered species present on military installations, without incurring either the costs of overpredicting presence when in fact absent or the consequences of conservation failure due to incorrectly concluding absence.

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Using Automated Radio Telemetry to Monitor Wildlife Activity and Movement Patterns

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David Delaney- I received my undergraduate degree in Wildlife Management from the University of New Hampshire and Master's of Science degree in Forestry, with a Wildlife Emphasis, from Northern Arizona University. I have been working in the natural resource field for over 15 years, primarily in threatened and endangered species research. Most recently I have been working on assessing the potential effects of human activity on priority threatened and endangered species on DoD and US Forest Service lands.

Automated radio-telemetry equipment is being used to monitor the activity patterns of tortoises at the National Training Center on Fort Irwin. The automated radio-telemetry equipment enables one person to monitor the activity of many tortoises continuously over an extended time, regardless of weather, light level or terrain. Data from radio transmittered tortoises are being transferred real-time by radio signal to a web accessible relational database. Data storage is accomplished through a central database capable of storing all data collected and capable of being served on the web. The website was developed as a dynamic front end to provide easy access to and visualization of the project's database. The database is continually updated via a live streaming data uplink and periodically updated through field observations. The website uses a complex user/password authentication schema that ensures integrity of the data is maintained. The type and/or amount of data the user is allowed to view are determined by user-group which adds additional security. This allows less sensitive information to be viewed by a wider audience, while maintaining a strict lock on sensitive data types that select users can view. The website allows users to easily view four primary categories of data: tortoise data, transmitter data, weather data, and maps. Data from this research project should benefit the recovery and management of desert tortoise populations through refinements in a number of research areas, e.g., temperature-based tortoise handling guidelines, baseline activity patterns, and translocation. Examples of field data and database tables will be presented.

Analysis of Gopher Tortoise Survey and Monitoring Techniques and Suggestions for Improvement

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Mr. Meyer is a Natural Resource Specialist with the Engineering Research and Development Center in Champaign, Illinois. His research areas focus on improving inventory and monitoring techniques of threatened and endangered species and on the geospatial analysis of fragmented habitats. He is pursuing an advanced degree in GIS Science related to Threatened and Endangered Species Management and holds degrees in Landscape Architecture, Environmental Studies, and Computer Information Systems.

Surveying and Monitoring of Threatened and Endangered Species (TES) are an integral requirement in successful implementation of the Endangered Species Act. The US Army Engineer Research and Development Center's Construction Engineering Research Laboratory (ERDC/CERL) in Champaign, IL, is engaged in research to examine threatened and endangered species population estimation techniques for accuracy in a variety of vegetative site conditions. Estimating TES population trends is essential to be able to track a species recovery progress. Yet, for many TES species this continues to be a difficult problem due to the wide variety of survey and monitoring methods employed for this purpose with incomplete knowledge toward their accuracy. This is especially true on military installations. Human and equipment resources vary according to the installation, as do available funds for studies. In order for installations to be able to make an informed choice about which technique to best apply they need information regarding the accuracy of population estimation techniques given differing levels of vegetative site condition.

To develop this information the gopher tortoise (*Gopherus polyphemus*) was selected as a test case species. The gopher tortoise was selected because it is not yet on the endangered species list in the majority of its home range, but may become listed. In the event of that occurrence the Army wants to be ready to respond to any mitigation priorities that could arise. The gopher tortoise is a terrestrial reptile that was once found throughout the Southeastern United States from North Carolina into Texas. However, due to numerous factors including human and animal predation and habitat loss they have been in decline for the past several decades. Populations often occur on military bases, where they have been protected from disturbance. Tortoises prefer open-canopied habitats with ample herbaceous ground vegetation for forage. Clearing trees to make openings at tank firing points and removing under-story to facilitate maneuver training has created good habitat, and the tortoises have moved in. Their presence poses a potential conflict to the training mission and makes them an important mitigation priority. ERDC/CERL in cooperation with the USGS, Florida Fish and Wildlife Cooperative Extension Unit of the University of Florida performed research comparing the strengths and weaknesses of Gopher Tortoise survey and monitoring techniques. The results of this study identify the strengths and weaknesses of each technique across varying site conditions with suggestions for new protocols to reduce bias and how to incorporate detection statistics. Lessons learned from this research will serve in the design of similar studies on surveying and monitoring for other high priority TES species on military lands.

Burrow Dispersion, Population Status, & Impacts Affecting the Gopher Tortoise (*Gopherus polyphemus*) at Avon Park Air Force Bombing Range, FL

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Al Kinlaw is a PhD Candidate in the Department of Wildlife Ecology and Conservation at the University of Florida, where he is researching the biodiversity of fauna utilizing gopher tortoise burrows as shelter sites. He obtained his Master's degree in Wildlife Management from North Carolina State University, where he worked on a capture-recapture study of spotted skunks at Canaveral National Seashore. He holds Bachelor's degrees from the University of Idaho (Wildlife-Fisheries Resources) and the University of North Carolina (Pharmacy). He has held biologist positions with state agencies in Florida, and is a practicing hospital pharmacist. The research presented at this conference was conducted at Avon Park Air Force Bombing Range, Florida, as part of a grant he co-wrote with David Maehr.

The Natural Resources Flight of Avon Park Air Force Range, Florida has embraced a mission to restore ecosystem condition by implementing inventory and monitoring systems and assess the impacts of military and natural resource management activities. The Range contains the gopher tortoise (*Gopherus polyphemus*), a Species of Special Concern, and ecologically considered a "keystone" species. I hypothesized that this reptile was abundant and that its burrows were clustered. Quadrat sampling was conducted in 4 upland habitats using randomly selected 1-hectare plots: 52 in oak scrub, 23 in sand pine scrub, 53 in pine flatwoods, and 17 in oak hammock were surveyed. Oak scrub had the highest density of burrows per hectare (1.473 burrows/ha, 95% C.I. 1.02-2.05) and 58.2 % of these plots contained active burrows. About a quarter of the pine flatwoods had burrows (mean: 0.453, 95% C.I. 0.23-0.70). The overgrown sand pine plots that were surveyed had not been burned prior to the survey, and had the lowest density (mean: 0.174, 95% C.I. 0.04-0.35). Oak hammock plots occurred on wetter soils and had a mean of 0.471, 95% C.I. 0.59-1.47). Spatial distribution of scrub burrows was fitted well by the negative binomial distribution, showing clumped burrows. Likelihood ratio tests combined with Akaike's Information Criteria showed that the best model for all 4 habitats was one in which the dispersion parameter (k) did not vary but the mean (m) did vary. A 67% occupancy rate of tortoises in oak scrub burrows yielded a population point estimate of 1761, with an asymmetrical confidence interval. Burrow density was lower than densities reported in other scrub areas of Florida. . Since the impacts had already occurred over previous years, no credible scientific evaluation was possible. I select one sub-impact under each land use practice, and show what experimental procedure needed to be done to evaluate each impact.

Monitoring Home Range Movements and Identifying Hibernacula of the Timber Rattlesnake and N. Pine Snake

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Ron is currently finishing his masters at Drexel University on the distribution of herpetofauna at Warren Grove Range in the Pinelands of Southern New Jersey. He is beginning a Ph.D. at Drexel University studying the spatial ecology of pine snakes and timber rattlesnakes. Ron is also a faculty member at Mercer County Community College where he teaches biology and anatomy & physiology courses

Warren Grove Gunnery Range (WGR) encompasses 9,400 acres of upland and lowland Pinelands habitats including large areas of the East Pine Plains and Oswego River Lowlands which supports populations of timber rattlesnakes (*Crotalus horridus*) and northern pine snakes (*Pituophis melanoleucus*). *Crotalus horridus* is a state-endangered species and *P. melanoleucus* is a state-threatened species, both of which occur in the Pinelands of southern New Jersey. We conducted a study at WGR to better understand the spatial ecology of *C. horridus* and *P. melanoleucus* and to determine if military operations impacted these populations. Key objectives of the study were to monitor home range movements, determine habitat preference, locate areas of high use, and record locations of hibernacula. During this study (fall 2002 through fall 2004), nine *C. horridus* and ten *P. melanoleucus* had radio-transmitters surgically implanted in the body cavity. We tracked snakes approximately once per week to monitor home range, core activity areas, and movements. Habitat use was different between the two species. *Crotalus horridus* occupied wetland habitats 69% of the time and *P. melanoleucus* occupied upland habitats 92% of the time. Both species utilized disturbed open areas throughout their established home ranges. Military operations did not impact the population of either species. A better understanding of the spatial ecology of these snakes at WGR will help natural resource managers to protect these state-listed species and to maintain military readiness.

Habitat Use by the Louisiana Pine Snake at Fort Polk, LA

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D. Craig Rudolph received Bachelor's and M.S. degrees in Zoology from the University of California at Santa Barbara, and a PhD. in Zoology from Texas Tech University. He is currently a Research Ecologist for the USDA Forest Service, Southern Research Station in Nacogdoches, Texas. His primary research interests center on fire-maintained pine ecosystems, with special emphasis on Red-cockaded Woodpeckers, Louisiana pine snakes, and lepidopteran communities.

The Louisiana pine snake (*Pituophis ruthveni*) has a limited range in eastern Texas and west-central Louisiana. Currently the species is rare and local in remaining blocks of suitable habitat. Large scale trapping studies throughout the historic range have refined our knowledge of the current status of the species. Extant populations appear to be confined to 3 small areas in Texas and 3 larger areas in Louisiana. Radio-telemetry studies on Fort Polk and other sites have found the species to be associated with fire-maintained pine forests, primarily longleaf pine, on sandy, well-drained soils. A close association with pocket gophers (*Geomys breviceps*) has also been documented. Pocket gophers provide the primary prey of adult Louisiana pine snakes, and their burrows provide shelter from temperature extremes, predators, and fire, as well as hibernation sites. Major threats to Louisiana pine snake populations include loss of forest habitat, alteration of historic fire regimes, mortality associated with roads, and commercial collection.

Fort Polk supports one of the largest blocks of fire-maintained longleaf pine forest remaining within the range of the Louisiana pine snake. On-going research on Fort Polk is designed to refine our knowledge of the distribution of the Louisiana pine snake on Fort Polk in relation to fire regimes, vegetation structure, soils, pocket gopher distribution, and the existing road network. Large-scale trapping for snakes in relation to the road network, censusing to determine pocket gopher distribution, and quantification of habitat variables relevant to Louisiana pine snakes are in progress to provide a comprehensive view of Louisiana pine snake distribution on Fort Polk. Survey data demonstrate an association with fire-maintained pine forests on sandy, well-drained soils, and a close association with pocket gophers as documented at other sites. However, Louisiana pine snake abundance on Fort Polk, inferred from trap success, is lower than in other occupied sites. Data on trap success in relation to the existing road network is not clear due to the relatively few Louisiana pine snake captures to date. However, the data being developed on Fort Polk should provide a basis for management of an important population of this rare species of critical conservation concern.

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SESSION 3A: HABITAT MANAGEMENT AND MANIPULATION

Opening Remarks- Peter Boice, Office of the Sectary of Defense--Conservation

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L. PETER BOICE is Conservation Team Leader in the Office of the Deputy Under Secretary of Defense, Environmental Security, Environmental Quality Division. He oversees the management of natural and cultural resources on DoD's 25 million acres of public lands. He also oversees DoD's Legacy Resource Management Program. He has participated in interagency and Departmental initiatives covering many issues, including ecosystem management, invasive species control, biodiversity conservation, wetlands, military overflights, recreational fishing, and conservation education. Mr. Boice has also served as Coordinator for DoD's Chesapeake Bay Program, and Program Manager for DoD's Underground Storage Tank, wetlands management, environmental planning and environmental awards programs.

Effects of Forestry Practices on Movement Patterns and Space Used by Gopher Tortoises

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Steve Bennett and Kurt Buhlmann are herpetologists with the South Carolina Department of Natural Resources.

John Nestor is a research technician at SREL.

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The gopher tortoise (*Gopherus polyphemus*) occurs in the southeastern Coastal Plain and has experienced widespread decline due to habitat loss and other human impacts. Although the species is currently listed as federally threatened in only the western portion of its range, many biologists believe additional protection throughout its range is warranted. The largest remaining populations occur on private lands (e.g., commercial timber lands) and military installations. Proper forest management at these sites will be critical to the success of the species. The goal of our study was to determine the response of gopher tortoises to forestry management practices as identified in the recovery plan for the red-cockaded woodpecker. We monitored habitat use of individual tortoises by radio-tracking adult gopher tortoises at four study sites having different ownership and management scenarios. They were: Ft. Gordon (military installation, winter burning), Savannah River Site (federal defense facility, winter burning, relocated population), Tillman Sand Ridge (SC state wildlife preserve, summer burning), and a private hunting preserve (no management). Fifty-nine tortoises (8-26 tortoises/site) were tracked 2-3 times/week for two years. General habitat data were collected to broadly characterize the canopy and herbaceous vegetation of each study site. Similar data were collected at active burrows to compare "tortoise-selected" vs. "available" habitat.

Habitat components varied significantly among study sites, primarily with respect to canopy cover and composition. Despite the differences in available habitat observed at the four study sites, the tortoise-selected sites (i.e., burrows) at each study location were remarkably similar to each other with respect to the vegetation parameters measured. Generally, tortoises selected burrow sites with lower canopy cover compared to the surrounding generally-available habitat, except at sites where canopy cover was already sparse. In addition to affecting availability of suitable sites for burrows, habitat conditions also influenced fidelity of adult female tortoises to those burrows, with highest burrow fidelity at the "growing season fire" site. Surprisingly, habitat conditions did not appear to affect home range size, which was similar among the three sites with naturally-occurring populations of tortoises. However, the paucity of juvenile burrows observed (but not quantified) at some sites, suggests the possibility that habitat conditions can have important implications for reproduction or recruitment—and ultimately demography—of tortoise populations.

The Forest Ecosystem Study:
Creating Biocomplexity in Young, Managed Forests

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Todd Wilson is a wildlife biologist for the Forest Service, Pacific Northwest Research Station, in Washington State. He has worked for the research station since 1991, focusing on a wide range of vertebrate species and their habitats, from old-growth forests to oak woodland-prairie ecotones to monitoring the effects of ecosystem manipulation studies. His bachelor degree was in wildlife biology, his master's degree in environmental studies focused on population genetics, and he is currently a PhD candidate in Forest Ecology and Management at the Union Institute and University in Cincinnati, Ohio. His doctoral work focuses on spatially-explicit individual-based modeling of flying squirrel nocturnal movement patterns and communicating his team's research results using new digital desktop multimedia tools.

Fort Lewis is listed as a Designated Conservation Area for the federally-threatened northern spotted owl because it is the largest remaining forested corridor connecting the Olympic Peninsula and Washington Cascades physiographic provinces. In 1991, the Forest Ecosystem Study (FES) was initiated on Fort Lewis to test whether variable-density thinning (VDT), cavity augmentation, and underplanting could accelerate key ecological processes in young, simplified forests, leading to forests high in complexity, including late-seral structural characteristics favorable for spotted owls. Two forests were studied—a 60-yr old unthinned forest with legacies of large live, dead, and fallen trees from the previous forest (Legacy Forest), and a 70-yr old forest that had been commercially thinned twice, and had a dense understory with little coarse woody debris (Timber Forest). Eight 13-ha stands were delineated in each forest. Experimental treatments (with controls) were implemented in 1993. Treatment effects were measured by monitoring key biotic communities, including arboreal rodents, forest-floor small mammals, resident and Neotropical birds, amphibians, fungi, litter invertebrates, and understory, mid-story, and overstory plants. Flying squirrels, the main prey of spotted owls, initially decreased in abundance after VDT, returned to pre-treatment levels within 5 years, but current populations remain low. Chipmunks increased sharply in Legacy stands treated with VDT and remained high in both control and VDT stands in the Timber Forest. Eleven years post thinning, most forest-floor small mammal species increased in abundance. The vagrant shrew initially increased in abundance, but has subsequently declined due to increasing understory development, while Keen's mouse, a dominant species in natural forest and virtually absent at the start of our study, returned to most stands in the Timber Forest. Resident and Neotropical birds increased in both species richness and abundance with increasing understory development. Truffle production initially decreased in stands treated with VDT, but diversity increased markedly and productivity returned to pre-treatment levels three years after VDT. VDT led to an initial reduction in understory cover, but 20 native and 11 exotic species increased in abundance. Three years later, understory cover returned to pre-treatment levels, species richness increased 150%, and only 4 exotics persisted in relative importance. Forest-floor invertebrates were influenced more strongly by past management history than by VDT. Overall results to date suggest that (1) VDT had positive or neutral effects for most organisms 2-11 years post-thinning; (2) prior management history had a major influence on treatment effects; (3) future success in accelerating complexity may depend on managing for spread of root rot and competitive exclusion by clonal natives; and (4) VDT appears promising as part of a suite of tools to create forests that can provide habitat for a wide range of plant and wildlife communities, including threatened and endangered species. Results from the FES have been incorporated into the management of Fort Lewis forests, as well as state, private, and other federal forests throughout the Pacific Northwest. Digital desktop multimedia products are being created to improve the communication of concepts and results from the FES to cooperators, clients, and interested public.

Endangered Bird Monitoring at Marine Corps Base Camp Pendleton

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Barbara E. Kus is a Research Ecologist with the US Geological Survey, Western Ecological Research Center in San Diego, and a Research Professor of Biology at San Diego State University, where she supervises graduate research in avian ecology and behavior. She received her Ph.D. in Ecology from the University of California, Davis, in 1985. Dr. Kus's primary research interests include the ecology and demography of the least Bell's vireo and other endangered riparian songbirds, the response of endangered species to cowbird management, the effectiveness of habitat creation and restoration as a tool for conserving riparian bird communities, and landscape-level analyses of the impact of urbanization on regional bird populations. She has worked extensively with wildlife and regulatory agencies, and is a member of several scientific advisory boards and endangered species recovery teams.

MCB Camp Pendleton is a 125,000-acre training installation in southern California, situated between Los Angeles and San Diego and providing the only break in the near-continuous band of urbanization along the south coast. Largely undeveloped, the Base supports a diversity of habitat types and is home to some 400 species of mammals and birds, including several endangered species. Among these are the federally endangered Least Bell's Vireo and Southwestern Willow Flycatcher, two riparian-dependent birds that have declined due to widespread habitat loss and cowbird parasitism. Once widespread in riparian habitat throughout California, these species were dramatically reduced in abundance and range and by the mid-1980s were restricted to a handful of sites, including Camp Pendleton. In addition to endangered species, Camp Pendleton provides breeding habitat for large populations of Neotropical migrants, including high-priority conservation species such as Yellow Warbler, Yellow-breasted Chat, Black-headed Grosbeak, and Swainson's thrush. Protection of sensitive species and their habitat is part of the Base's dual mission of promoting combat readiness and environmental stewardship. USGS provides science support for this mission through research and monitoring designed to monitor bird population trends and evaluate response to management. In the nearly 20 years since the Least Bell's Vireo was listed, recovery-oriented management at the Base has focused on cowbird control and, more recently, eradication of invasive plants from riparian areas. Annual cowbird trapping since 1983 has virtually eliminated parasitism and increased productivity of vireos, which have increased from 27 territories in 1981 to over 1,000. Research by USGS documented that cowbird parasitism is the single most important factor influencing vireo productivity at Camp Pendleton, accounting for 62% of the annual variability in production of young. In contrast, parasitism is weakly related to willow flycatcher productivity, and flycatchers have shown little sustained increase in abundance in the same habitats and under the same management as vireos. These findings suggest that while parasitism substantially limits vireo population growth, something other than parasitism currently limits willow flycatchers. Current USGS research to identify these limiting factors is addressing habitat requirements, adult and juvenile survival, and dispersal. Removal of the exotic plants Giant Reed (*Arundo donax*) and Tamarisk (*Tamarix* sp.) is being conducted over large areas of the Base to encourage re-establishment of native riparian vegetation and create additional habitat for riparian species. USGS is monitoring removal sites to evaluate the short- and long-term effects on distribution, density, and nesting success of vireos and flycatchers, as well as other riparian birds. Point counts documented a negative linear relationship between bird species richness and cover of Giant Reed, suggesting that exotics removal will increase both richness and abundance of riparian birds. USGS operates two MAPS (Monitoring Avian Productivity and Survival) banding stations in riparian habitat at Camp Pendleton. Mark-recapture data collected through this standardized, constant-effort protocol is analyzed to document population trends of local riparian birds and contributes to a national program monitoring Neotropical migrants. In addition, data obtained through MAPS provide a means for documenting response to natural catastrophes and extreme events, which since 2002 at Camp Pendleton have included record-breaking high and low rainfall years, and wildfire. Information on natural climatic variability and the associated response of species provides an essential context within which to evaluate the status of biological resources and the effectiveness of resource management.

Management of California Least Terns and Western Snowy Plovers on Navy Lands in San Diego Bay

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Naval Base Coronado (NBC) is comprised of seven distinct installations that are distributed over an area of 3,380 square miles in San Diego and Los Angeles Counties in southern California. The mission of NBC is to equip, maintain, train and support Naval surface and aviation units of the Pacific Fleet and other operational forces in order to conduct military operations in support of the Navy's operational commanders. To support this mission our conservation program manages 42,573 acres of land and water across some of most diverse ecosystems in the continental United States. Although our program is comprehensive and multifaceted the primary focus is the management of federally listed species and their habitats. NBC supports 25 federally listed species, including the federally endangered California Least Tern (*Sterna antillarum browni*) and federally threatened Western Snowy Plover (*Charadrius alexandrinus nivosus).* Aggressive monitoring and management efforts have, over time, increased the population of these species to the point where their presence has come in conflict with required training objectives. For example on the Navy's ocean beaches tern nests have grown from one in 1994 to 577 in 2004 and the plover nests have grown from three in 1992 to 63 in 2004. Due to this increase in population the Navy has had to work with the US Fish and Wildlife Service, California Department of Fish and Game, as well as other cooperators to reduce conflicts by trying to discourage nesting. Results of management techniques, the success of methods used to discourage nesting, and what obstacles are facing the future will be discussed.

The Culvert Test Bed Facility: A Research Tool for Enhancing Fish Passage

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Dr. Christopher W. May, senior research scientist and engineer at the Battelle Marine Sciences Laboratory (MSL), is a freshwater ecologist and environmental engineer with expertise in urban watershed assessment and management. His areas of interest include stormwater management, low impact development (LID), watershed analysis using geographic information systems (GIS), salmonid habitat assessment, urban stream rehabilitation, water quality monitoring, stream biological assessment, and watershed restoration. His current research at Battelle focuses on the linkage between upland watersheds and nearshore-marine ecosystems, including natural processes and land-use impacts. Prior to joining the MSL team Dr. May was a research engineer at the University of Washington Applied Physics Laboratory (UW-APL). His research there centered on the cumulative impacts of urbanization on native salmonids in small streams in the Puget Sound lowland eco-region. Dr. May is an adjunct faculty member of Western Washington University, Huxley School of Environmental Studies, University of Washington, Tacoma Environmental Science Program, and the University of Washington, Professional Engineering Program.

The passage of juvenile salmonids and other fish through culverts is a significant Endangered Species Act (ESA) issue throughout the Pacific Northwest and now in other areas of the nation. Much of recent research and engineering has focused on increased passage of returning adult salmon; however, juvenile salmonid movement both up and downstream throughout the year is now recognized as substantial and is a key area in which future research promises practical returns. Because a large percentage of the culverts beneath roads in the Pacific Northwest are judged as blocking juvenile salmon from thousands of miles of habitat, determining appropriate hydraulic and fish-passage designs for retrofitted culverts before installation has both substantial cost and environmental implications.

The Culvert Test Bed (CTB) facility and research program is being operated by an interdisciplinary team of scientists and engineers from Pacific Northwest National Laboratory (PNNL) to address the hydraulic and behavioral issues associated with juvenile salmonids and other fish passage through culvert systems. This program addresses the testing and assessment of full-scale physical models of culvert systems deployed in an experimental test bed. Experiments in the test bed have begun and will measure the hydraulic conditions associated with various culvert designs under various slopes and flow regimes, and then relate these measures to repeatable, quantitative measures of fish-passage success.

The CTB program is a one-of-a-kind capability designed to provide scientifically sound information that can be used to develop better designs for retrofitted culvert installations. Compared with field studies or temporary installations, the facility promises fast results, scientific and statistically controlled evaluations, an ability to quickly discern optimum engineering principles, and elimination of expensive trial-and-error approaches of field installations.

Response of Gopher Tortoises to Habitat Management by Prescribed Burning at Camp Shelby Training Site, Mississippi

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Mathew Hinderliter got his Bachelor's degree from Clemson University in 1991, and after 9 years in corporate America decided to go back for his Master's degree. He received his MS in Zoology from the University of New Hampshire in 2003, and his thesis research involved radio-tracking spotted turtles in southern New Hampshire. He is currently living near Hattiesburg, Mississippi with his wife Holli and newborn baby daughter, and is the new Gopher Tortoise Biologist working for The Nature Conservancy at the Camp Shelby Training Site.

The Camp Shelby Training Site (CSTS) in Mississippi is currently the only military installation where gopher tortoises (*Gopherus polyphemus*) are federally listed as threatened. However, declining populations in other parts of their range could potentially have impacts on 17 additional military installations. On CSTS, gopher tortoises are concentrated on open training areas, because shrub encroachment has reduced the herbaceous groundcover in the surrounding forests. To investigate whether reintroducing prescribed fire into these forested areas would improve habitat conditions and increase tortoises' use of forests, eight sites were selected. Four sites were burned during the winter of 2001/2002 and again in April 2003; four control sites were not burned. Changes in vegetation measured at sample points on the sites each spring from 2001-2004 indicated that burn treatments did not increase herbaceous vegetation. However, herbaceous vegetation continued to decrease at the control sites, suggesting that even though the two burns were insufficient to improve habitat conditions, they may have at least prevented further deterioration of conditions. Comparisons between populations of radio-tracked tortoises from 2002-2004 indicated that movement patterns, burrow usage, and home range did not differ significantly between treatments. There was an initial reduction in shrub cover in the forests after burning, and subsequent burrow surveys showed that the largest percentage of new burrows found were in forested areas on burned sites. This suggests that once shrub cover is reduced, tortoises may start using forests that either have never been used or have become overgrown. However, stem densities later increased, indicating that shrub reduction was temporary. Since gopher tortoises are such a long-lived species, some individuals have probably been using the same burrows for decades. It is therefore likely that if a tortoise is almost exclusively using burrows on open grassland areas, there would have to be long-term improvement to the surrounding habitat in order for that individual to be inclined to make an immediate, permanent home range shift. It is also likely that any real changes in the movement patterns and habitat usage of a population of tortoises will only become evident in a long-term study. In many of the areas, additional annual burns, more intense burns, herbicides or mechanical methods are necessary to restore the open canopy, sparse woody mid-story, and abundant herbaceous vegetation that gopher tortoises require.

Habitat Management and Population Recovery of Eggert's Sunflower (*Helianthus eggertii* Small) on Arnold Air Force Base, Tennessee

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Kevin C. Fitch: School: Austin Peay State University Clarksville, TN: MS/BS in Biology, (research and teaching assistant for the Center of Excellence in Field Biology). 1998: Bureau of Land Management, Medford Oregon: supporting the Northwest Forest plan by surveying for amphibian and terrestrial gastropods and participating in spotted owl research. 1999-2005: Arnold Air Force Base / Arnold Engineering Development Center, TN: I have developed and administered/managed a Plant Ecology (i.e., inventory and monitoring) program for the 39,081 acre base. Additionally, I am a member of the prescribed fire management team and assist with the partners in flight monitoring program.

Eggert's sunflower is the only federally listed "threatened" plant species known from Arnold AFB, TN (AAFB). AAFB's Conservation program implements adaptive management projects to accomplish recovery objectives outlined for the species by the US Fish and Wildlife Service. Historically, management actions were integrated with other aspects of the AAFB ecosystem management program by employing a coarse-filter fine-filter approach. The coarse-filter approach outlined a strategy to restore and maintain vegetation structure and ecological processes in suitable habitats for Eggert's sunflower. Such process-oriented management supported mission flexibility by working at multiple spatial and temporal scales to conserve biodiversity. Fine-filter protective measures ensured that localized destruction of the species or its habitat do not encroach on mission flexibility by violating provisions of the Endangered Species Act. In 2004, AAFB and the USFWS signed a Cooperative Management Agreement (CMA). This agreement outlines a strategy to continue the coarse-filter protective measure while removing fine-filter management requirements. The CMA provides for long-term conservation of the species on AAFB through the implementation of management activities that concur with the habitat requirements of the species. Management strategies for long-term conservation of the species consist of restoring and maintaining the Barrens Mosaic conservation target (within 3,544 acres). Restoration and maintenance prescriptions mimic the natural disturbance regimes that increase the spatial distribution and abundance of Eggert's sunflower. The CMA extends until June 2006, at which point the Air Force's management commitment will be incorporated into the base's Integrated Natural Resources Management Plan.

Linking Habitat and Demography for Assessing Species Viability and Evaluating Recovery Targets

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*H. Resit Akçakaya is Senior Scientist at Applied Biomathematics (Setauket, NY), an ecological research and software company. Dr. Akçakaya is a quantitative ecologist with experience in modeling, risk assessment, metapopulation dynamics, and population viability analysis. He has over 80 publications in conservation biology and theoretical ecology; he is a co-author of two textbooks (*Risk Assessment in Conservation Biology and Applied Population Ecology*), and the lead editor of Species Conservation and Management: Case Studies, which includes population and metapopulation models for 37 plant and animal species. One of the principal architects of the RAMAS software library, Dr Akçakaya developed models for risk assessment and modeling of metapopulations, for integrating metapopulation dynamics with geographic information systems, and for incorporating uncertainty into IUCN criteria for threatened species. He served on the Criteria Review Working Group of the IUCN, and is currently chair of the IUCN Red List Standards and Petitions Subcommittee, which develops guidelines for threatened and endangered species assessments, and evaluates petitions against the red-listing of these species. He also serves on the editorial boards of* Conservation Biology and Population Ecology.

Threats such as habitat fragmentation, land use and management, invasive species, and urban encroachment affect species through their habitat and demography. Habitat effects include increased isolation, reduced habitat quality, and decreased connectivity. Demographic effects include reduced fecundity (e.g., due to nest parasitism), increased mortality (e.g., from roads or due to competition with invasive species). Thus, both habitat and demography must be considered in assessing the viability of TER-S on DoD and adjacent lands, or in evaluating recovery targets and mitigation options. In addition, for many species, habitat is not static, but changes. The changes can have predictable trends (e.g., forest succession or urban sprawl) or can be random (e.g., fires, droughts). How well a species reacts to changing habitats depends on its demographic characteristics, such as population growth rate, dispersal rate, density dependence, etc.

We present a new approach that not only allows considering a species' habitat and demography together, but also incorporates habitat dynamics. This approach combines habitat-based metapopulation models, statistical habitat models, and landscape models to link the species' demography and its dynamic habitat. It allows an integrated assessment of impacts on threatened, endangered, and at-risk species, and provides a quantitative framework for evaluation mitigation and management options. This approach builds on the RAMAS software tools for habitat-based viability analysis, and extends these tools by incorporating dynamic changes in species' habitat. The habitat-based viability approach has been applied to several species, including golden-cheeked warbler, California gnatcatcher, California least tern, red cockaded woodpecker, desert tortoise, western snowy plover, sage sparrow, and sharp-tailed grouse. The results of these applications indicate that species viability and recovery are strongly affected both by the species' habitat (including its area, quality, and spatial structure) and by its demography (including survival and fecundity). Ignoring effects of either habitat or demography leads to biased estimates of species viability, chances for its recovery, and the optimal management options.

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- Metapopulation dynamics of the California Least Tern. *Journal of Wildlife Management* 67:829–842.
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- Assessing human impact despite uncertainty: viability of the Northern Spotted Owl metapopulation in the northwestern USA. *Biodiversity and Conservation* 7:875-894.
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SESSION 4A: IMPACT ASSESSMENT

Opening Remarks- Steve Hodapp, US Army Engineer Research Development Center—Construction Engineering Research Laboratory

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Mr. Steve Hodapp is currently employed by the Army's Engineer Research and Development Center where he serves as Program Manager for the agency's Threatened and Endangered Species Research Program. Research on threatened and endangered species research has been determined by the Army to be its highest priority conservation research requirement. Mr. Hodapp also serves as the Co-Chair for SERDP's Conservation Technology Thrust Area Working Group. Prior to his assignment with the Army in 1999, Mr. Hodapp worked for the Department of Agriculture, Farm Service Agency where he developed the Conservation Reserve Enhancement Program. Before working for the Department of Agriculture, Mr. Hodapp worked for 7 1/2 years as professional staff on the House Resources Committee where he was assigned issues relating to the National Park Service, cultural resources, wild and scenic rivers and outdoor recreation. Prior to working for the House Committee, Mr. Hodapp worked for the National Park Service for 18 years. His assignments with the National Park Service included Chief, Resource Management and Research at Grand Canyon National Park where he worked on issues relating to re-regulation of Glen Canyon Dam, air quality and aircraft overflights. Mr. Hodapp received a BS in wildlife management from the University of Wyoming and pursued graduate studies in wildlife management at Virginia Tech.

Ecological & Environmental Acoustic Remote Sensor (EcoEARS) Application for Long-Term Monitoring and Assessment of Wildlife

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Co-Authors- Stuart H Gage, Subir Biswas, and Robert C. Maher, Ph.D.

Gonzalo Sanchez is the President of Sanchez Industrial Design Inc. His work is in the area of transportation noise and acoustics. He is also involved in the design, manufacturing and installation of specialized electronic hardware used to collect both acoustic and environmental data. He holds a BS in Biomedical Engineering from Boston University.

Dr. Stuart Gage is a Professor of Entomology at Michigan State University. His research and teaching interests are in the areas of Biological Information Systems and Earth System Science. He is also the Associate Director of the Center for Global Change and Earth Observations and Director of the Computational Ecology and Visualization Laboratory. He holds a BS degree in Agriculture from North Dakota State University and both MS and PhD degrees from Michigan State University in Entomology & Systems Ecology.

Dr. Rob Maher is an Associate Professor of Electrical and Computer Engineering at Montana State University-Bozeman. His research and teaching interests are in the application of modern digital signal processing techniques to problems in digital audio and acoustics. He holds a BS degree from Washington University in St. Louis, an MS degree from the University of Wisconsin-Madison, and a Ph.D. from the University of Illinois-Urbana, all in Electrical Engineering.

Acoustic signals produced by birds, amphibians, insects, and other organisms, collectively comprising the *Biophony*, are a valuable ecological attribute. Combined with sounds caused by human activity (the *Anthrophony*) and sounds due to water, wind, geologic activity (the *Geophony*), acoustic signals can provide information about the function of ecosystems. Because acoustic signals change hourly, daily, seasonally and annually, environmental acoustics must be measured at these time scales, yet the frequency range and temporal dynamics of acoustic signals can defy our ability to measure and classify the signal properties. To measure acoustics at appropriate temporal scales and simultaneously measure at appropriate spatial scales can also be challenging and costly. Fortunately, the application of innovative sensors, computational platforms, and communication network technologies is providing new opportunities and enabling new insights into the meaning of acoustic signals in the environment. The new strategies and technologies help optimize the scope and geographic coverage of these measurements while reducing human labor. In addition, we have developed analytical technology and computer software to classify environmental sounds into the Anthrophony, Biophony and Geophony groupings, thereby providing a method to categorize a habitat and assess its ecological integrity. Real-time interpretation remains a challenging problem, but we have also successfully demonstrated algorithms to identify in real-time human made sounds generated by jets, propeller aircraft, helicopters and motor vehicles, which will be used to better understand the effects of these human made sounds on the environment. Signal analysis techniques to identify wildlife and simultaneous collection of environmental parameters like wind, rain, solar radiation and temperature will be used to study the interactions among these variables and to monitor changes and trends in the environment.

The instrumentation we utilize for measurement of environmental acoustics ranges from commercially available computer systems with automated recording software to specially constructed hardware designed to measure and archive environmental acoustics at timed intervals. We have developed automatic methods to transmit acoustic signals via satellite to remote servers where the signals can be archived, processed and classified without human intervention. We will describe the field deployable hardware used to monitor acoustics, the cyber infrastructure required for large scale acoustic monitoring, and the methodology used to automate the classification of acoustic signals. We will also discuss future requirements for design of networks for long-term environmental monitoring.

Ecological Risk Assessments for TER-S and Wildlife Management

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Mr. Smith is a research biologist with the US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory. Previously he has held management and research positions with the US Air Force, the Wisconsin Department of Natural Resources, the US Natural Resources Conservation Service, and the US Fish and Wildlife Service.

Some of the current work Mr. Smith is involved with includes that investigating impacts and effects of military related environmental stressors on fish and wildlife, the competitiveness of native plant species in the face of exotic weed invasions, and wildlife disease implications for threatened, endangered and at-risk species on military installations. Other work has included that addressing native plant establishment, endangered and other species reintroductions, waterfowl production and mortality, ungulate biology, wildlife damage and abatement, wetland development and management, and human and wildlife interactions. Mr. Smith is a graduate of Iowa State University and the University of Wisconsin.

Ecological risk assessment is a developing field of study and application. Historically, ecological risk assessment applications have focused chemical stressors and general ecological consequences of exposure. However, ecological risk assessment approaches also have a place in relation to wildlife and other natural resources management planning, environmental impact assessments and statements under the National Environmental Policy Act, biological assessments related to the Endangered Species Act, and other applications. Ecological risk assessment can have utility for fisheries and wildlife biologists and managers and other natural resource management professionals. Recently there has been and interest and effort to refine and use structured approaches to apply ecological risk assessment methodologies to address impacts and effects of military activities on wildlife and other natural resources. An overview of a historical and legal background for ecological risk assessment, Environmental Protection Agency guidelines, current approaches particularly as used by the Department of Defense, and specific examples of ecological risk assessments in multiple and single species applications is presented.

Quantitative Investigation of Military Training Noise Effects on Bat-Activity at Fort Knox, Kentucky

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Chester O. Martin is a Research Wildlife Biologist with the Environmental Laboratory, US Army Engineer Research and Development Center. He received B.S. and M.S. degrees in Wildlife and Fisheries Science from Texas A&M University and is a Certified Wildlife Biologist. He has conducted bat research on numerous military installations and Corps of Engineers projects. Chester is currently Chair of the Bat Working Group of the National Military Fish and Wildlife Association and Mississippi Bat Working Group, and serves on the Executive Committee of the North American Bat Conservation Partnership. He has authored/co-authored over 130 papers in professional journals, technical reports, and other media, including 30 articles on bats.

Military noise can potentially affect wildlife, including threatened and endangered bat species, and is a concern on Department of Defense installations. However, quantitative information regarding bat response to high-energy noise sources is lacking, and noise impact studies are needed to address conflicts between military training and endangered bats. We conducted an investigation of military noise, primarily high-caliber weapons fire (HCWF), on bat activity on Fort Knox, Kentucky, during 2002-2004. The 44,000 ha installation is home to the US Army Armor Center, supports abundant HCWF training exercises, and has known populations of gray bats (*Myotis grisescens*) and Indiana bats (*M. sodalis*). Research objectives were to evaluate the impacts of military training noise on bat activity and bat selection of foraging areas. Our null hypothesis was that training noise has no effect on critical bat functions.

Our study represented an innovative approach that employed a combination of sampling and data collection techniques, including standard mist-netting, ultrasonic sound detection, thermal infrared (TIR) imagery, and noise monitoring technology. Quantitative data consisted of simultaneous measurements of bat activity and noise events, simultaneous measurements at firing and reference sites, and measurements collected before, during, and after firing events at multiple locations. Sony TCD-D8 DAT recorders were used to simultaneously record all sound events. Anabat II detectors were used to monitor ultrasonic vocalizations. TIR imagery was collected using Indigo TVS-620 long-wave (8-12 micron) imagers. Combined mist-netting and ultrasonic detection revealed the presence of 11 species of bats on the installation, including gray and Indiana bats.

Measurements of ultrasonic sound, TIR, and military noise were subjected to rigorous statistical analysis within and among sample sites. The experimental design for 2003 data consisted of simultaneously monitoring firing sites and comparable reference sites; data were subjected to a nested ANOVA with factors (date, site, activity). In 2004, emphasis was placed on monitoring sites at the same range site during firing and non-firing periods. Data were analyzed using a two-factor factorial with repeated measures; factors were location and event. Our analysis showed extremely large variations in bat response variables across space and time, and there were no consistent significant differences in measures of bat activity associated with military noise at a fixed site, firing and reference (non-firing) sites, and type of military noise. We concluded that our data did not provide enough evidence to show that elevated noise levels associated with HCWF had any measurable impact on bat navigation and foraging behavior.

Effects of Transient Training Disturbance on Black-Capped and White-Eyed Vireos at Fort Hood, Texas

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Mr. Hayden has been a research ecologist at the Army Corps of Engineers, Engineer Research and Development Center in Champaign Illinois since 1991. Mr. Hayden has performed field research to evaluate effects of military training on endangered avian species at Fort Hood, Texas and Fort Stewart, Georgia. He has participated in developing biological assessments and management plans for endangered red-cockaded woodpeckers, black-capped vireos and golden-cheeked warblers. Prior to joining the Corps of Engineers he was a Research Associate at the University of New Mexico studying raptor populations in the southeastern New Mexico. He has an M.A from the University of Missouri and is currently a Ph.D. candidate at the University of Illinois.

Research was conducted during 2001-2004 on Fort Hood, Texas to evaluate effects of transient human disturbance on physiology and behavior of the endangered black-capped vireo (*Vireo atricapilla*) and a closely related congeneric, the white-eyed vireo (*Vireo griseus*). In 2001 and 2002, corticosterone was measured to evaluate whether white-eyed vireos were chronically stressed in areas with intensive armored maneuver training activities. Baseline and stress-induce corticosterone levels were not significantly different in sample populations from areas with intensive training activities versus areas with limited training activity. In 2003 and 2004, nest attendance and habituation in response to controlled flushes were evaluated for both black-capped vireos and white-eyed vireos. Researchers flushed adult birds from nests during incubation stage, and this flush was repeated on four consecutive days to evaluate habituation to disturbance. Response variables measured included distance the attending flushed from the approaching observer, whether the adult returned within 20 minutes, time to return of adult bird, and sex of attending and returning bird (black-capped vireo only). Mean distance from observer of the first flush was approximately 1.0 m for both species. Flush distances did significantly decrease with subsequent trials. In black-capped vireos, female were more likely to be attending the nest upon approach, but males were more likely to return to the nest post-disturbance. White-eyed vireos were less likely than black-capped vireos to return to the nest within 20 minutes, but black-capped vireos were more likely to reflush from the nest when the observer left the area.

Military Smoke and Obscurant Effects on Fish and Wildlife

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Mr. Smith is a research biologist with the US Army Corps of Engineers, Engineer Research and Development Center, Construction Engineering Research Laboratory. Previously he has held management and research positions with the US Air Force, the Wisconsin Department of Natural Resources, the US Natural Resources Conservation Service, and the US Fish and Wildlife Service.

Some of the current work Mr. Smith is involved with includes that investigating impacts and effects of military related environmental stressors on fish and wildlife, the competitiveness of native plant species in the face of exotic weed invasions, and wildlife disease implications for threatened, endangered and at-risk species on military installations. Other work has included that addressing native plant establishment, endangered and other species reintroductions, waterfowl production and mortality, ungulate biology, wildlife damage and abatement, wetland development and management, and human and wildlife interactions. Mr. Smith is a graduate of Iowa State University and the University of Wisconsin.

Modern military tactics and training require the use of many technologies, many of which can be land use intensive and potentially impact threatened, endangered, at-risk, and other species. Military smoke and obscurants have widespread use and application in military training protocols. However, the ecological impacts and effects of military smokes and obscurants have been relatively little studied. We summarize information on the toxicology of military smokes and obscurants and present information derived from continuing studies on a wide phylogenetic range of species, as well as chemical composition and deposition. These studies have involved five different smokes and obscurants in variable time, distance, and weather, field and laboratory exposures. Exposures have included House Sparrows (*Passer domesticus*), Red-winged Blackbirds (*Agelaius phoeniceus*), and Brown-headed Cowbirds (*Molothrus ater*); northern leopard frog (*Rana pipiens*); several species of fish including fathead minnows (*Pimephales promelas*), rainbow trout (*Oncorhynchus mykiss*), and Endangered Species Act listed fountain darters (*Etheostoma fonticola*) and Topeka shiners (*Notropis topeka*); aquatic insects (*Chironomus* sp.); aquatic crustaceans (*Daphnia* sp., *Ceriodaphnia* sp.); and aquatic plants (*Potamogeton* sp., *Selanastrum* sp.). Results of all exposures indicate little or no short term (up to 96 hrs.) toxicological effects on the species involved. Also, no long term (3 week) effects have been noted in the plant species. Similarly, no adverse effects on hatchability of eggs, fledgling success, and survivability of house sparrow young were observed. Additionally, no acute or clinical indications of toxicity, abnormal behavior, weight loss, or lesions related to exposure were observed in red-winged blackbirds. Further study is expected to provide information useful in threatened, endangered and at-risk species management and recovery, toxicology, and sustaining military capability.

Assessing Contaminant Sensitivity of Endangered and Threatened Freshwater Fish and Mussels

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Dr. Ning Wang is a Research Fisheries Biologist with the U.S Geological Survey, Columbia Environmental Research Center. He received his Bachelors (1982) from the Huazhong Agricultural University at Wuhan in China and his Diploma (1991) and Doctorate (1994) from the University of Constance at Konstanz in Germany. Prior to his current position, he worked at the Limnological Institute at Konstanz in Germany as research scientist for one year and did postdoctoral research at the University of Missouri for three years. He has been engaged in teaching and research in the field of ecology of fishes and aquaculture. Since 1998 he has conducted research to evaluate the sensitivity of endangered and threatened fish to contaminants using acute and chronic toxicity tests. During the past few years, he has also worked with USFWS, USEPA, and ASTM in developing standard methods for conducting early life-stage toxicity tests with freshwater mussels.

The US EPA water quality criteria (WQC) for the protection of aquatic life are primarily based on responses of surrogate species routinely cultured and tested in the laboratory. Results from these tests are assumed to represent the sensitivities of untested species. Relatively little information is available about the chemical sensitivity of endangered and threatened (listed) species to evaluate this assumption, and toxicity data for freshwater mussels have not be routinely used to establish WQC. During the past 15 years, a series of acute or chronic early life-stage toxicity tests with several organic or inorganic toxicants were conducted with 12 listed freshwater fish, 4 listed mussel species, 6 common test organisms (fathead minnow, *Pimephales promelas*; sheepshead minnow, *Cyprinodon variegatus*; rainbow trout, *Oncorhynchus mykiss*; cladocerans, *Daphnia magna* and *Ceriodaphnia dubia*, and amphipod, *Hyalella azreca*), and 11 other mussel species. Results of 4-d acute tests with fish indicated that rainbow trout was more sensitive to copper, carbaryl, 4-nonylphenol, permethrin, and pentachlorophenol than the other two common test fish (fathead minnow and sheepshead minnow) and was equal to or more sensitive than listed fish species 81% of the time. Results of 30- to 60-d chronic tests with fathead minnow, rainbow trout, and 2 listed species (fountain darter, *Etheostoma fonticola*; spotfin chub, *Cyprinella monacha*) suggested that fountain darter was the most sensitive species for copper and pentachlorophenol but spotfin chub was no more sensitive than the common test species. Effect concentrations observed in these fish tests were generally above the current WQC. In contrast, the results of 2-, 4-, 10-, and 28-d toxicity tests with larval (glochidia), newly-released juvenile, or 2-month-old juvenile mussels of all species tested, including the 4 listed species, demonstrated that early life stages of mussels were generally more sensitive to copper and ammonia than the most sensitive of 5 common test species of fish, cladocerans, or amphipod. Effect concentrations of copper and ammonia observed in mussel tests were typically at or below the acute or chronic WQC, indicating that the WQC might not provide adequate protection to mussel species including the listed species tested. Therefore, toxicity data generated from mussel tests should be considered to develop the WQC. In the interim, protectiveness of acute or chronic WQC for listed fish and mussel species could be improved by applying a safety factor of about 0.5.

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Tools to Evaluate Management Options for Threatened Fish in the Columbia River Basin

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Jim Petersen: I grew up in Idaho, got a degree in Biology at Boise State University in 1976, spent a year studying coral reefs at the University of Queensland (Australia) on a Rotary Foundation Fellowship, and received a Ph. D. in marine ecology from the University of Oregon in 1983. Since 1983, I worked as a researcher with the Natural History Museum of Los Angeles County (5 years; kelp ecology and power plant impacts in the near-shore marine environment) and then as a fisheries biologist with the federal government (16 years; predation on salmonids in the Columbia River Basin, impacts of climate change on fish, bioenergetics modeling of fish, and native fish in the Grand Canyon). Currently, I'm the laboratory director of the Columbia River Research Laboratory, part of the US Geological Survey. In this capacity, I oversee a large team that conducts research throughout the Pacific Northwest, with smaller efforts in Klamath Basin, California, and Nevada.

The Columbia River Research Laboratory, part of the US Geological Survey, conducts research on fishery issues in the Columbia River Basin. Our goal is to provide reliable and timely information to resource managers, such as the US Army Corps of Engineers, to support their decision-making process. Most studies are conducted to assist in the recovery of threatened, endangered, or rare species within the region, such as Pacific salmon, steelhead, bull trout, lamprey, and white sturgeon.

Juvenile salmonids are monitored during their downriver migration to estimate survival rates, evaluate passage routes, and describe behavior near dams. During each year, a large numbers of salmonids are radio-tagged (>20,000), and tracked through the lower Snake and Columbia Rivers using fixed and mobile antennas. Mark-recapture methods are used to estimate relative rates of survival and to compare survival through various routes or to test specific hypotheses. Other studies have used acoustic tags to evaluate the behavior of juvenile salmon in The Dalles Dam forebay and to monitor white sturgeon movements in response to dredging activities in the lower Columbia River. Studies in smaller tributary systems often use passive integrated transponder (PIT) tags and fixed antenna systems to detect the movements of fish. Habitat and growth models are developed and used to better manage water releases, temperature, and spill from dams.

Results of studies are evaluated by technical work groups, composed of federal, state, and tribal fishery managers within the Columbia River Basin, that are considering management alternatives. The data and analyses from research projects have assisted in the development and evaluation of a variety of management actions, such as the construction and operation of juvenile fish passage systems at Bonneville and John Day dams. Results have also aided in the recent development of removable spillway weirs that are being installed on several Snake and Columbia River dams. These weirs use a smaller volume of water to efficiently pass fish. Research results are also being used to select the timing and volume of spilled water at dams, to evaluate water release strategies to improve juvenile salmonid rearing and adult spawning, to plan guidance structures in dam forebays, and to evaluate the efficiency of the removal of small barriers. Examples will be provided of these various tools, models, analyses, and management applications.

Integrating Soldiers and Skullcaps: Lessons from the Management of a Spring Ephemeral

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Laura Phillips Lecher is currently the Natural Resources Manager for the Tennessee Army National Guard. She has been with the Environmental Office of the TNARNG for 2.5 years, her first experience with the National Guard. Her academic background includes a B.S. in natural resources from the University of the South in 1992 and a M.S. in forest resources from Penn State University in 1996. Her work experience prior to coming to the TNARNG was varied: inspecting x-ray machines for the state of Tennessee; riding stable instructor and assistant barn manager; a year as an intern with the forestry crew at Fort Polk, Louisiana; field technician for the USFS Coweeta Hydrologic Lab; and of course teaching and research work in graduate school. Her research interests and publications range from forestry and plant ecology to endangered species habitat and historic land use patterns.

In 2000, the Tennessee Army National Guard (TNARNG) identified that their Volunteer Training Site in Catoosa, Georgia (near Chattanooga, Tennessee), likely contains suitable habitat for a Federally-listed Threatened plant, the large-flowered skullcap (*Scutellaria montana*). This set in motion a series of processes and struggles as the TNARNG worked first to determine and quantify the species' actual presence and locations and then to align the military mission at Catoosa and conservation goals for *S. montana*. The initial sampling in the May-June flowering season of 2002 found 1581 individuals in 60 clusters (grouped into 26 management units) scattered across the approximately 1600 acre training site – a significant portion of the known Georgia population of this species. A plot-based monitoring protocol was developed and implemented for the first time in 2004. Forty-six 10-m radius circular plots located within *S. montana* management units were inventoried, and 1122 plants were located in that 3.6 acre combined sample. Additionally, in 2005 the TNARNG placed approximately 180 endangered species warning signs around the 26 management units to notify troops of restricted access areas. The next steps will be to continue to monitor the population trends of the sampled management units.

Learning to manage this vegetation resource has required collaboration among multiple external organizations (GADNR, USFWS) to develop and implement the monitoring protocol, identify protective measures (e.g., buffer zones, informational signs), and inform soldiers and managers for effective coexistence of the Guard and the skullcap. The TNARNG has been successful in its endeavor to ally military and conservation in 2003-2005: (1) the pest management coordinator worked with the environmental office to develop a road-side weed control plan to assure no accidental herbicide application to *S. montana*; (2) the construction office consulted with the environmental office to minimize the impact of security fence construction on the western property boundary; and (3) the training site manager and range officer brought the environmental office in at the planning stage on a new range development project to be sure *S. montana* plants were not threatened by the placement of the new range. Thus, the technical information is truly being utilized and applied at multiple levels by a variety of users. Three key points became apparent through this progression: 1) internal communication, cooperation, and compromise are essential; 2) collaboration with external agencies should be initiated early in the process and maintained; and 3) plans are not inviolate – they keep improving to achieve the optimal benefit for both the soldiers and skullcaps.

SESSION 4B: SPECIES AND HABITAT CONSERVATION

Opening Remarks- Reed Noss, University of Central Florida

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Reed Noss is the Davis-Shine Professor of Conservation Biology at the University of Central Florida and an international consultant and lecturer. He has a B.S. in Education from the University of Dayton, a M.S. in Ecology from the University of Tennessee, and a Ph.D. in Wildlife Ecology from the University of Florida. He has worked as an ecologist for the Ohio Department of Natural Resources, Florida Natural Areas Inventory, and US Environmental Protection Agency during his 30-plus years in the environmental field. Dr. Noss is the author of over 220 scientific and semi-technical articles and several books: Saving Nature's Legacy (1994), coauthored by Allen Cooperrider; The Science of Conservation Planning (1997), coauthored by Michael O'Connell and Dennis Murphy; The Redwood Forest (2000), which he edited; and two co edited books: Ecological Integrity, (2000) and Large Mammal Restoration (2001). The first and last of these books have won major book awards.

Dr. Noss was Editor-in-Chief of Conservation Biology, the leading journal in the field, from 1993 through 1997, is Past President of the Society for Conservation Biology (1999-2001), and is currently President-Elect of the North American Section of the Society. From 1993 through 1996 he held a Pew Scholars Fellowship in Conservation and the Environment. In 1995 he won the Edward T. LaRoe III Memorial Award of the Society for Conservation Biology. He is certified as a Senior Ecologist by the Ecological Society of America and is an elected Fellow of the American Association for the Advancement of Science. He serves on many boards, committees, and advisory panels, including the Board of Governors of the Society for Conservation Biology and the Board of Trustees of the Florida Chapter of The Nature Conservancy. His present research involves the application of science to conservation planning at regional to global scales. He lives with his family in Chuluota, Florida.

Conserving Species and Ecosystems

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The first stated purpose of the US Endangered Species Act is to "provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved." In part because the Act provides no directives for how to conserve ecosystems, implementation of the Act usually has been species-by-species and often site-by-site. In recent years, however, many land managers have emphasized ecosystem-based approaches, which ostensibly are more efficient than species-by-species approaches, better consider ecological and evolutionary processes, and reduce conflicts between the needs of different species. Ecosystem management is the leading paradigm for federal lands, and multi-species habitat conservation plans (HCPs) and recovery plans are increasingly common. The State of California has a Natural Community Conservation Planning (NCCP) program, which shows considerable promise. However, critics allege that individual species often receive less protection under these various plans. In addition, some of the most rapidly advancing areas of research in conservation biology involve use of focal species and spatially explicit population modeling and viability analysis in conservation planning. In addition, the concept of keystone species (or highly interactive species) has received increased support. Clearly there is a need to reconcile species-based and ecosystem-based conservation and management. I provide examples from several regions of approaches to reconciling species and ecosystem conservation, as well as some remaining problems and questions. Use of multi-species or community indices of biotic integrity, carefully selected focal species and population models, and attention to natural processes on several spatial and temporal scales are recommended.

Species at Risk on DoD Lands: Quantifying Opportunities for Conservation

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Nancy Benton is a project manager at NatureServe in Arlington, Virginia, where she manages regional and national scale conservation projects with the US Department of Defense, the Fish and Wildlife Service, the Bureau of Land Management, and with private organizations. Previously, Nancy worked as a research botanist at The Nature Conservancy. She has a master's degree in Conservation Biology from the University of Maryland.

In collaboration with the Department of Defense (DoD) and the US Fish and Wildlife Service, NatureServe carried out a study designed to quantify the number of species at risk found on or adjacent to military installations. The goal of this study was to identify opportunities for proactive conservation that could prevent plants and animals on DoD lands from declining to the point where formal Endangered Species Act (ESA) protection would be required. Our study looked at that suite of "species at risk" that are not protected under the ESA. Of 729 DoD installations analyzed, we found that 224 (30%) contain at least one species at risk. Of the 523 species at risk found on these installations, 47 are candidates for federal listing, 136 are classified by NatureServe as critically imperiled, and 340 classified as imperiled. Based on these data, management guidelines were developed for key species at risk on four DoD installations. Funding is being sought to extend this work to additional installations. NatureServe has recently released a decision support system, Vista, to assist users in multi-scale conservation assessment and planning. Using Vista, users can meet their conservation objectives through analysis of compatibility between policy scenarios and the needs or sensitivities of various elements (species, communities, ecological systems and non-biological elements such as historic and cultural sites, and DoD training ranges). Proactive conservation efforts informed by our analysis and tools hold great promise for enabling DoD to continue meeting its military training mission while carrying out its environmental stewardship responsibilities.

Developing a Database to Track Status and Trends for Populations

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Peter A. Dratch is the Endangered Species Program Manager with the NPS Biological Resource Management Division. Before NPS, he worked for the US Fish and Wildlife Service as one of the scientists who started the National Fish and Wildlife Forensics Laboratory, and in the Washington Office of Scientific Authority. He has also worked for the Oregon Department of Fish and Wildlife, the Laboratory of Genomic Diversity of the National Cancer Institute, and the New Zealand Ministry of Agriculture and Fisheries. Peter has a B.A. from The Evergreen State College and a Ph.D. from the University of Edinburgh

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Loyal A. Mehrhoff is the Chief of the Biological Resource Management Division of the National Park Service. Prior to that, he was a staff biologist for the US Fish and Wildlife Service in the Office of Technical Support where he worked on Issues related the Northwest Forest Plan. Loyal has three degrees in Botany, a B.A. from the University of Montana, an M.A. from the University of North Carolina, and a Ph.D. from the University of British Columbia.

Fagan Johnson, Database/Web Administrator and Ecologist, Colorado Natural Heritage Program, 242 General Services Bldg, CSU, Fort Collins, CO 80523; Tel: 970-491-4628 faganj@lamar.colostate.edu

Fagan has been at the Colorado Natural Heritage Program since 1999 and has over 11 years experience in biological sampling, GIS mapping, using computers to analyze/display biological data, and technical writing. Fagan has also worked at the North Carolina Sate University Aquatic Botany Laboratory as the Lab Manager for the Wilmington Coastal Laboratory.

There are currently 455 federally listed or proposed species in 188 units of the National Park Service (NPS). These species are represented by 932 current populations, 253 historic populations, and 10 populations that have been restored to their former habitat. To track the status and trend and expenditures for each park population, NPS has developed the NPS Endangered Species Act (ESA) Database. Trend for each population is assessed annually and classified as increasing, stable, not-at-risk, declining, extirpated, or unknown. The Database also provides NPS species recovery tasks. The Database includes the annual NPS expenditures for each species, which is transferred to the Fish and Wildlife Service for national reporting under the Environmental Conservation Online System. This information is also made available to the public on a web page of the NPS Biological Resources Division; visitors can ask which listed and candidate species occur in any national park, which parks have a particular species, and how much NPS spends on a species each fiscal year. To promote endangered species recovery, NPS has also developed management summaries for listed species enabling parks to determine the pertinent publications and the management or recovery plan goals that they should be addressing. These summaries have been developed in conjunction with the Colorado Natural Heritage Program at Colorado State University. Both the NPS ESA Database and the supporting materials are tools that could prove useful to the Department of Defense and other agencies that share recovery responsibilities for these species.

Discovery of a New Species on a Military Training Area and its Consequences

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Dana Quinney has worked as a research associate and/or habitat biologist for the USDA Insect Research Service, Oregon State University, the University of Arizona, the University of Idaho, Colorado State University, and the USDI Bureau of Land Management. She has been an environmental Program Manager with the Idaho Army National Guard since 1988 and has worked in the Idaho desert for over 25 years. She manages the Army Guard's biological monitoring, rare species, invasive species, research, and restoration programs.

Jay Weaver is the Idaho Army National Guard's Natural Resources Technician and has worked for the Idaho Army National Guard since 1989. His specialties are native species restoration, NEPA surveys, and rare plant research. Jay takes many of the photographs used in IDARNG's environmental awareness program.

Scott Quinney was educated in England as a biologist and for twelve years has served as the Environmental Awareness Program Manager for Idaho Army National Guard. Formerly a graphics designer and magazine editor, Scott designed advertising campaigns for such companies as Clorox and Hewlett-Packard. Scott creates environmental posters and cards, presentations and other training materials, and training videos for Idaho Guard soldiers. He also creates IDARNG community and agency outreach materials.

What happens when a species new to science is discovered on a military training area? Several years ago Idaho Army National Guard biologists Dana Quinney and Jay Weaver discovered a large fairy shrimp in temporary waters of one of the playa lakes in Orchard/Gowen Field Training Area. They collected specimens but were unable to key them out to known species. Eventually they found shrimp taxonomist Christopher Rogers, who compared the large shrimp to other species and determined that the reason it would not key out, was that it was new to science. Rogers, Quinney, and Weaver described the new species; this paper has been accepted for publication by the *Journal of Crustacean Biology*. The new species is over three inches long, and is a predator. Rather like an aquatic preying mantis, the new shrimp captures and kills smaller species of fairy shrimp. Quinney and Weaver elected to co-author the description; this will ensure that, should the species prove to be rare and need protection, that IDARNG's interests will be represented on all panels and review boards dealing with the conservation of the species, since they are authors of the species.

Metapopulation Genetic Dynamics of Two Endangered Songbirds

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Richard F. Lance is a Research Biologist with the Environmental Genetics & Genomics Team in the Environmental Laboratory, US Army Engineer Research and Development Center. He received B.S. in Zoology from Brigham Young University and a Ph.D. in Evolutionary and Environmental Biology from the University of Louisiana at Lafayette. He has conducted population genetic studies on endangered birds, endangered mussels, invasive mussels, bat species of concern, and native grasses. He has particular interest in genetic methods for tracking species behavior and population trends, and in noninvasive sampling methods for sensitive species.

Threatened and endangered species (TES) on military installations often exist as subpopulations within larger metapopulations. Gene flow (dispersal of breeders between subpopulations) can be essential to maintaining genetic diversity and reducing inbreeding. However, gene flow into installation subpopulations may be threatened by regional habitat fragmentation, and by the extinction of nearby subpopulations. The impacts of reduced gene flow are exacerbated by small effective population sizes, and effective population sizes are reduced when habitat degradation results in smaller patch size or increased variance in reproductive success among breeders.

On Fort Hood, TX, two TES songbirds, the Golden-cheeked Warbler (*Dendroica chrysoparia*; GCWA) and Black-capped Vireo (*Vireo atricapillus*; BCVI), may be part of larger metapopulations. For each species, we are assessing gene flow within Fort Hood, and between Fort Hood and other sites within the species' breeding ranges. We are also testing hypotheses about fundamental interactions among landscape, habitat, and metapopulation genetics (gene flow and diversity). These relationships are likely to be complex for both species, because breeders may disperse as a function of spring migration, and not directly between natal subpopulations.

Currently, we are sampling GCWA and BCVI subpopulations that occur on Department of Defense, US Fish and Wildlife, State of Texas, and private lands. In 2004, 50 samples from each species were obtained from 3 distinct areas on Fort Hood. In 2005, another 100 samples from each species will be obtained from 4-5 distinct locations. An additional year of sampling is planned for 2006. Sampling consists of taking a small blood sample (~ 2 µl) and 2 secondary feathers from each bird. While blood samples will serve as the primary source of DNA for our study, we are also testing feather-based techniques that represent a less stressful approach for future work.

We evaluated 40 Passeriform microsatellite DNA markers for use in our studies of GCWA and BCVI. Of these microsatellites, 17 were found in GCWA, while 19 were found in BCVI. Exploratory analysis of microsatellite marker frequencies in GCWA subpopulations on Fort Hood indicates that some differentiation may occur across relatively small geographic scales.

In upcoming years (2006-08), we will apply recent advances in population genetic theory, such as Bayesian Assignment Tests, to the determination of genetic patterns in GCWA and BCVI. The fundamental knowledge that we are developing may, in the future, allow installations to predict how regional and local habitat fragmentation will impact the TES populations they manage.

Desert Tortoise Hatchery Project at Edwards Air Force Base

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Eric Peffer is a contracted biologist for CH2M HILL at Edwards Air Force Base, California. Since 2001, Eric has worked in the consulting field with the desert tortoise. He obtained his degree in Ecology and Systematic Biology from Cal Poly, San Luis Obispo in 1994 and is currently working on his Master's.

Several factors have been identified in the continuing decline of the Mojave population of desert tortoise (*Gopherus agassizii*). To recover this species, methods must be employed to decrease mortality and increase natality. To be considered a successful technique, tortoise hatcheries must increase the number of individuals recruited into adult breeding age classes. The tortoise hatchery program established at Fort Irwin has produced results that warrant repetition in a stressed/diseased environment. This hatchery project, involves collecting free ranging gravid female desert tortoises and placing the animals in predator proof enclosures. After females deposit their eggs in the enclosures they are released back at their original capture site and are radio-tracked throughout the year. Enclosures are designed to provide protection for the eggs and hatchlings. Hatchlings are held in the enclosures for a predetermined amount of time and then released into the wild. Started in 2003, ongoing efforts are expected to provide answers or information to research questions such as: what factors influence hatchling mortality, can released yearlings survive well, does irrigation increase growth rates and speed up maturation to a predator-resistant size, how serious is predation by ground squirrels, does the program cause yearling mortality, is there vertical disease transmission of diseases, do multiple males contribute to clutch paternity, what is the genetic variability of the population at Edwards AFB, what is the genetic variability of populations throughout the Mojave desert? Edwards Air Force Base is employing an adaptive management strategy in the execution this project. If successful, this technique should be conducted as a multi agency effort, throughout the geographic range of the desert tortoise.

Blanding's Turtle Research and Nest Protection at the Camp Ripley ANG Training Site, MN

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Co-Author: Brian Dirks, Natural Resource Specialist, Minnesota Department of Natural Resources, Camp Ripley Environmental Office, 15000 Highway 115, Little Falls, MN 56345.

Julie DeJong: BS in Wildlife and Fisheries Sciences from South Dakota State University MS in Wildlife Sciences from South Dakota State University Masters work with nongame grassland birds in western South Dakota. Employed as a wildlife biologist with Minnesota DNR for 4 years at the Camp Ripley Army Training Site.

Turtle populations throughout Minnesota have declined due to human activity. The Blanding's turtle (*Emydoidea blandingii*), a Minnesota state listed threatened species, is dependent upon a variety of wetland types for normal activities and upland sandy soils for nesting. Camp Ripley Army National Guard Training Site, located in central Minnesota, contains one of the largest intact, undeveloped tracts of Blanding's turtle habitat in the state. Two Master's theses and seven years of additional research have provided information on habitat associations, reproductive output, and sensitivity to military activity. Current focus is on locating previously undiscovered habitats and protection of nests. Gravid female Blanding's turtles typically nest in sandy upland habitats, which at Camp Ripley are often roads or trails. Road surveys and ground searches are conducted in areas of known or potential nesting habitat to locate turtles during peak nesting period (June). Once located, turtles are monitored until nesting is completed. Upon nest completion, the turtles are captured, marked for identification, weighed and measured. Radio-transmitters are attached to certain turtles in order to monitor movements back to wetlands. Nests are protected with wire exclosures and monitored until hatching, a mean of 83 days. Unprotected nests are often destroyed by predators within 24 hours. Protected nests (N=12) have had a 66.6% success rate. Average turtle clutch size is 16 eggs with an average hatch rate of 93%. Long term survival of the Blanding's turtle in central Minnesota may depend upon the successful management of the species on Camp Ripley.

Identifying and Managing Habitat for Endangered Karst Species at Camp Bullis, Texas

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Dr. George Veni is an internationally recognized hydrogeologist specializing in caves and karst terrains. Since 1987 he has owned and served as principal investigator of George Veni and Associates. Much of his work has been in central Texas, but he has also conducted extensive karst research throughout the United States and in several other countries. He serves as a doctoral committee advisor for geological and biological dissertations at The University of Texas and teaches karst geoscience courses as an adjunct professor for Western Kentucky University. He has published and presented over 100 papers, including four books, on hydrogeology, biology, and environmental management in karst terrains.

Camp Bullis Military Training Site has proved a role-model for research and management of endangered karst species. Located in central Texas on the edge of San Antonio, the 113.3-km2 reservation was known to have nine caves when nine karst invertebrates were proposed for endangered listing in 1992. Detailed surveys of the installation revealed nearly 100 caves and 1,300 karst features to date, including 23 caves with species federally listed in 2000 as endangered, plus four caves with a state-listed threatened species of aquatic salamander, and 28 caves with at least 17 non-listed invertebrate and vertebrate karst species endemic to Camp Bullis. Identification of the species' habitat was the result of grid searches for caves, excavation of karst features and within caves, repeated in-cave biological surveys during various microclimatic conditions, and rearing immature troglobites to adulthood for full identification. The presence of these many rare and endangered species localities has not interrupted training at Camp Bullis. Establishment of a karst species management plan with the US Fish and Wildlife Service has excluded Camp Bullis from critical habitat. The plan calls for continued research as needed to better define habitat, monitoring of the ecosystems, aggressive control of fire ants, study and management of rare non-listed species to reduce the need for future listing, the delineation of biological and hydrological protection zones, and coordination of military training that is effective at supporting Camp Bullis' mission yet is appropriate for those zones.

APPENDIX E:
Hawaii Working Group Discussion

Hawaii Working Group Discussion

- Marine Corps Priorities
    - Invasive species control (e.g., fountain grass)
    - Feral Ungulate Control
    - Prevention of Invasive Species Introductions
    - Population Viability Analyses
    - Defining Optimal Habitats and Carrying Capacity
    - Quantitative Methods to Define Success of Management Approaches
- USFWS Priorities
    - Landscape Analysis of Resources
    - Identify Conservation Priorities
    - Restoration and Stabilization of Habitat
- Forest Service Priorities
    - Breaking invasive species, wildfire cycle
    - Experimental Forest on Big Island
- University of Hawaii Priorities
    - Limitations in Research Integration
    - Problem-Solving Science to Address Specific Questions
    - Technical Expertise and Stronger Partnerships
- Comprehensive comparison of all habitats represented on military property, compare to habitat remaining on lands under other ownership, assess the burden that DoD can logistically be expected to bear - build on Hawaii GIS-based gap analysis (nearly complete), look for conservation opportunities at low elevations
- Identify research and implementation gaps based on recovery plans
- Identify adjacent property owners as potential mitigation partners (e.g., Makua), principally the NPS and use of existing programs to control invasive species
- National Invasive Species Council made a recommendation to establish early detection networks for flora and fauna (e.g., invertebrates) for military lands, Hawaii Invasive Species Council is target for DoD partnerships
- Inventory and Monitoring Program of NPS (protocols), 32 networks
- NPS has summarized all recovery plans for species in its parks
- Conservation Funders Working Group is potential resource, Craig Rolland
- Research on prevention/detection technologies (specifically for brown tree snake and fire ants) and biocontrol for invasive species, as well as restoration plans to follow invasive species control efforts
- Research on improved fencing/barrier technologies for feral pigs would have an immediate impact (reference NPS and TNC for lessons learned)
- There is a need to demonstrate and validate inventory and monitoring technologies against a known population size to establish standards
- Outreach, monitoring, and rapid response for invasive species control
- Funding for action/operations in the field is needed more than research related to invasive species and monitoring of TER-S

APPENDIX F:
Pre-Event Challenges and Issues Matrix

Challenges	Research and Monitoring Issues
TER-S Impacts	
Long-term threats to TER-S on military installations include increasing isolation and "island" effect from incompatible land uses outside the fenceline.	Standard TER-S assessment methodology for all DoD facilities that can be used with multiple species to efficiently evaluate and monitor habitat quality and potential encroachment or fragmentation.
	Availability of monitoring data to researchers off-site so species can be managed at the population level.
	Shift focus of research on TER-S from habitat usage and impacts on a small scale to negative anthropogenic impacts on large-scale ecosystems.
Characterizing how management activities as well as military training and testing affect TER-S and habitat.	Long-term monitoring is essential to establish baselines and to analyze trends -- cannot assess impacts or recovery without the status quo.
	Map reference conditions (e.g., original fire frequency and original vegetation) for ecosystem.
	Develop a comprehensive management plan for each TER-S and appropriate monitoring schedule.
	Noise, smokes, and obscurants.
	Erosion and control measures.
	Translocation of Desert Tortoise.
	Bald eagle population movement and the impact of delisting species on affected installations.
	Determining impacts of training on the sustainability of migratory bird species of concern.
Minimizing mission impacts to TER-S and habitat.	Long-term sustainability of natural ecosystems found on military lands.
	Accurate assessment of species' presence or absence. Improvements in sampling and monitoring equipment and techniques and sampling design are needed to support such assessments.
	Non-invasive techniques must be explored in order to more effectively monitor sensitive species and predict and mitigate potential impacts of activities.
	Habitat preservation and restoration for TER-S.
Assurance that DoD is using the best available science to guide management and recovery efforts.	Use of science-based monitoring that includes addressing spatial variation and detectability.
Lack adequate or valid monitoring protocols. Protocols are inconsistent, which complicates the analysis and interpretation of data.	Monitoring protocols, techniques, information management, and analysis for habitat and species.
	Availability of resources for natural resource management staff to receive training, use validated techniques, and conduct consistent monitoring.
Synthesizing information on multiple TER-S that occur on the same tract of land. How does one effectively balance the needs of competing species?	
Addressing invasive species that threaten TER-S habitat (i.e., invasive species interactions).	Early detection, monitoring, management, and control of invasive species.

Challenges	Research and Monitoring Issues
Training Impacts	
	Conflict with mission readiness preparation and TES habitat and monitoring requirements.
Balancing need to train soldiers and test systems with need to protect rare species and their habitat, while still promoting recovery subject to public review.	Guarantee of stable populations, suitable/available habitat, and ecosystem function alongside of a trained and ready military force.
Spatial and temporal limitations to military training and testing (e.g. military flying operations) from TER-S encroachment resulting from increased development and diminished green space.	Need accurate understanding of real, versus speculative, effects of training and testing activities on each taxon so that reasonable safety margins may be implemented to the end that the success of both the mission and the species is ensured.
Uncertainty in ecological risk assessments has the potential to inadequately estimate risk involved in training leading to costly cleanup efforts, reductions in training, or insufficient protection of TER-S.	Lack of scientific information exists for assessing the impact of military unique activities on TER-S.
Compliance	
Potential increases in listing actions for TER-S.	Recovery of listed species.
Ensuring compliance and long-term recovery, while maintaining mission within budgets. History shows that DoD can comply with protection of TER-S without mission degradation.	Research is essential to recovery of species locally and regionally; however, the cost effectiveness of such research as well as monitoring must be addressed.
Mechanics of Management	
DoD must convince the public and legislators that it is committed and doing an admirable job of managing TER S. Indeed, many species exist on DoD lands because of the nature of disturbances that occur.	Determining the degree and nature of disturbance-dependence of T&E species on DoD lands.
Loss of institutional knowledge as a result of outsourcing. Installations need long-term on-site staff, not contractors, for continuity of management.	Long-term personnel who are dedicated to the future of military training and have been in place long enough to project future needs, not contractors.
Developing partnerships with agencies and non-governmental organizations (NGO) to impact conservation before a species needs to be listed.	Proactive conservation for species-at-risk.
Coordinating conservation research with community outreach, as well as military training.	Outreach of habitat condition and trend knowledge.

APPENDIX G:
Workshop Agenda

TER-S Workshop

(by invitation)
1:30pm – 5:00pm, Thursday, June 9

Workshop leads: Bob Holst (SERDP) and Steve Hodapp (ERDC)
Facilitation: Alison Dalsimer (HGL)
Online Scribe: Alicia Shepard (HGL)

Agenda

1:30 – 1:40: Welcome and workshop purpose (Bob Holst, SERDP)

1:40 – 2:10: Identification of key issues; organize issues into broad categories

2:10 – 2:15: Divide into not more than 4 working groups; designate group lead

2:15 – 2:30: BREAK

2:30 – 3:55: Working group discussion (pre-selected leader; HGL scribe)

4:00 – 4:45: Reconvene and report back: Provide 4 top priorities w/ suggestions re main R&D issues, timing, what agency/org should take lead (10 mins/group, if 4 groups). Leads: Rachel Muir,

4:45 – 4:55 Volunteer for follow up meeting; select meeting date/location (*bring your calendars!*)

4:55 – 5:00: Wrap up statement (Steve Hodapp, ERDC)

APPENDIX H:
Workshop Attendee List

Thursday Workshop Participants (25)

Workshop Steering Committee (11)
Peter Boice, OSD-ATL*
Paul Dresler, USGS*
Dan Friese, AFCEE/ECS*
Lew Gorman, USFWS
Heidi Hirsh, Marine Corps HQ
Steve Hodapp, ERDC-CERL*
Bob Holst, DoD SERDP
Lorri Schwartz, Navy NAVFAC
Bea Vanhorne, USDA FS
John Wiens, TNC
Bill Woodson, CTR, US Army HQ*

HGL Support Staff (5)
Alison Dalsimer
Sean Donahoe (subcontractor)
Leslie Orzetti
Alicia Shepard
John Thigpen

Session Chairs not listed above (1)
Joan Walker, USFS

Other (8)
Peter Dratch, NPS
Tim Hayden, COE
Tom Heffernan
Rachel Muir, USGS
Bruce Rittenhouse, NPS
Brad Smith, SERDP
Dave Tazik, COE
Kurt Fristrup, Cornell Laboratory of Ornithology

* indicates session chair