PROCEEDINGS FROM THE

PACIFIC ISLANDS REGION THREATENED, ENDANGERED, AND AT-RISK SPECIES WORKSHOP

6-8 JUNE 2006
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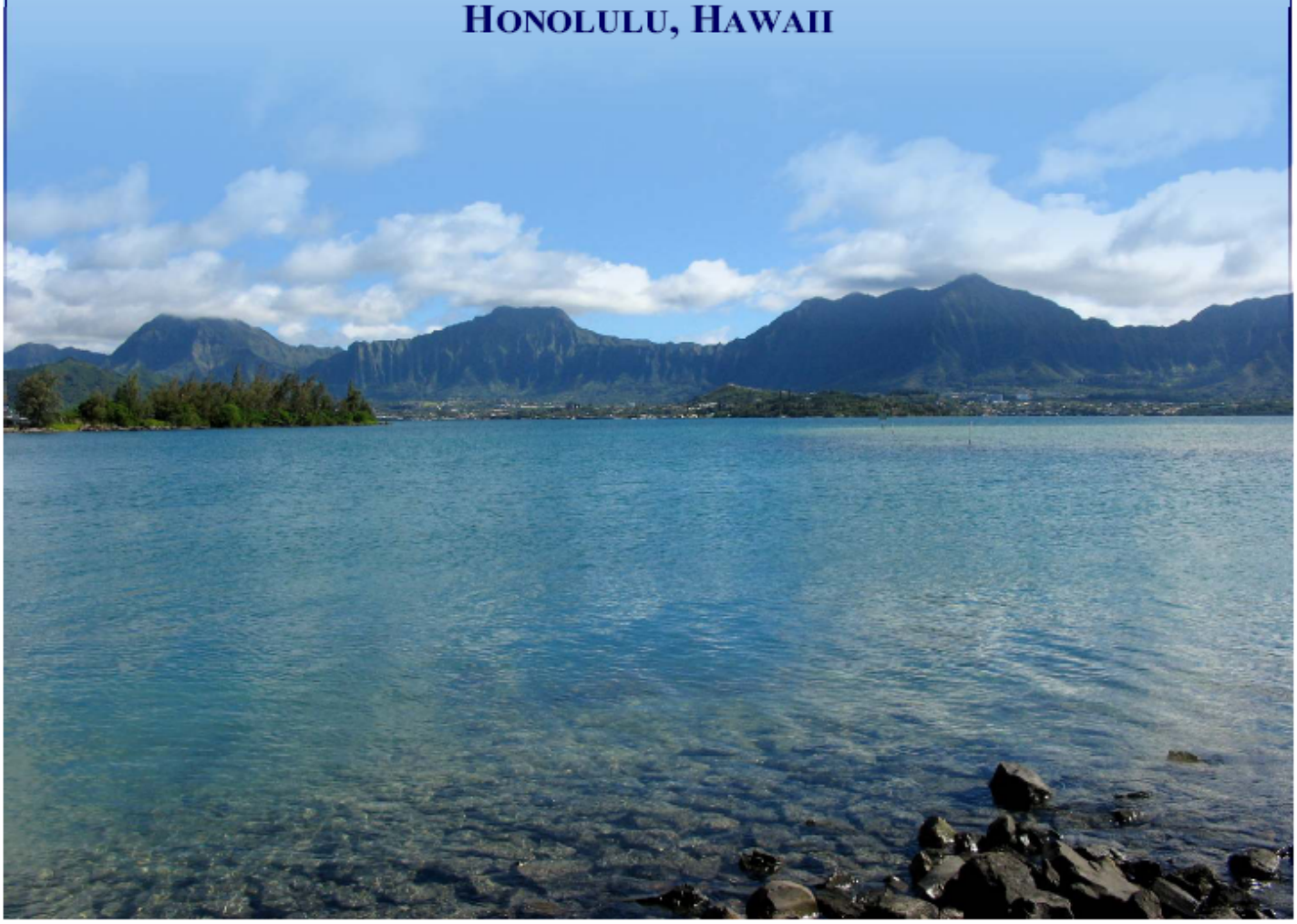

These proceedings encompass outcomes from the *DoD Pacific Islands Region Threatened, Endangered, and At-Risk Species Workshop*, and reflect the opinions and views of workshop participants, and not necessarily those of the Department of Defense. This document is available in PDF format at www.serdp.org/tes/pacific.

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Cover photo: *View from Waterfront Ops station at Kane'ohe Bay* – Leslie Orzetti.

EXECUTIVE SUMMARY

The Department of Defense (DoD) manages nearly 30 million acres of land and thousands of square miles of air and sea space to conduct missions vital to United States national security. These same lands and sea space provide habitat for a great diversity of plants and animals, some of which are found only under DoD stewardship. Nowhere else do DoD lands harbor greater biological diversity than in the Pacific Region. Yet, this vibrant and diverse ecology is under immediate and significant threat, especially from development and urban expansion, non-native invasive species (NIS), and the changing military mission. Currently, NIS are especially of concern. With one new species becoming established in Hawaii every 18 days, and approximately 10 percent of these species becoming invasive, the issue is significant and timely.

DoD has a vested interest in maintaining training and testing capabilities throughout the Pacific Region. DoD presence is greatest on the Island of Guam and among the Hawaiian Islands, where there are more than 15 military installations and ranges encompassing over 200,000 acres of land. In addition, these lands contain at least 100 threatened or endangered species.

Through a collaborative effort, DoD's Strategic Environmental Research and Development Program (SERDP), Environmental Security Technology Certification Program (ESTCP), and Legacy Resource Management Program (Legacy) sponsored the *Pacific Islands Region Threatened, Endangered, and At-Risk Species (TER-S) Workshop* held 6-8 June 2006 in Honolulu, Hawaii. This workshop was the first in a planned series of regional TER-S workshops recommended at a national symposium addressing TER-S on DoD and adjacent lands held in June 2005 (see www.serdp.org/tes for more information).

The specific objectives for the Pacific Islands Region TER-S Workshop were to: 1) identify and prioritize TER-S management needs among the Pacific Region Islands; 2) examine the current state of practice within DoD for TER-S management; 3) identify the gaps in knowledge, technology, and management; and 4) prioritize investment opportunities to address these gaps. To achieve these objectives, workshop sponsors and organizers brought together a broad spectrum of discipline experts from the research and management communities, including federal and state agencies, academia, and the non-governmental conservation community.

The workshop's plenary session consisted of presentations from Hawaii's State Department of Land and Natural Resources, the Bishop Museum, and the Hawaii Army National Guard. Overviews were provided on the state of aquatic and terrestrial ecosystems, and participants toured Marine Corps Base Hawaii to learn how DoD natural resource management personnel deal with the challenge of how to effectively use lands, air, and sea resources for national security missions while simultaneously conserving species protected by the Endangered Species Act and those at risk of needing such protection.

The following two days consisted of breakout group discussions on the following topics:

- *Individual Species Approaches: Remaining Critical Questions*
- *Ecosystem Management*
- *Impacts of NIS on TER-S*
- *Synthesis and Prioritization of Aquatic and Terrestrial Issues*
- *Technology Transfer*

Except for the synthesis session, each session comprised three concurrent breakout groups focused on specific aspects of a topic. Workshop discussions elucidated a number of information gaps that could be addressed by research (SERDP), technology or method demonstration (ESTCP), or assessment of particular management approaches applicable to multiple DoD installations (Legacy). In addition, participants also identified a need for better communication and data sharing among regional stakeholders.

This proceedings document summarizes workshop discussions and identifies priority information gaps. The table below provides a synthesis of the top aquatic and terrestrial recommendations. Participants identified both general information gaps and those specific to a particular species, group of species, or habitats. These distinctions are captured in the table as appropriate. The aquatic category also includes topic areas that could be addressed in a watershed context.

Table 1: Highest Priority Aquatic and Terrestrial Information Gaps

Aquatic	Terrestrial
Biological inventory, recent status trends, ecological function, and military impacts for Pearl Harbor, inner Apra Harbor, freshwater streams on Guam and upper stream reaches on Hawaiian Islands, and aquatic caves	Methods for and phasing of native habitat restoration, especially dry forests
General approaches for NIS early detection, rapid response, pathway assessment, and control methods in both freshwater and marine environments	Ecological approaches to breaking the non-native grass-wildfire cycle
NIS potential for spread (pathway assessment) between Okinawa and Guam and Hawaii (on account of military force realignment)	Brown tree snake control methods
Biofouling of ship hulls as a pathway for NIS introduction	Management of invasive vertebrates, especially rodents and ungulates
Management of NIS algae and seaweed	General approaches for NIS early detection and rapid response
NIS control, especially ungulates, and habitat restoration within a watershed context	General detection methods for TER-S
Non-linear (threshold) responses to ecosystem perturbations and their effects on TER-S	
Remote sensing technologies for aquatic health assessment	
Standardization of NIS policies and management procedures and NIS/TER-S regional inventory protocols	

In examining priorities within each of the categories, it becomes clear that invasive species issues, the dry forest ecosystem, and standardization of protocols were the top concerns expressed by workshop attendees.

By considering recommendations resulting from this workshop, SERDP, ESTCP, and Legacy can help address ecological threats in the region by targeting program resources towards conservation-related research, demonstration, and management efforts that support species and habitat protection goals, while maximizing training and testing flexibility.

Overall, participants gained a better understanding of existing regional partnerships, and established new personal and professional connections through which they can work to better integrate research, management, and collaborative initiatives to benefit TER-S in the region.

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LIST OF ACRONYMS

BMP	Best Management Practice
CESU	Cooperative Ecosystem Studies Unit
CGAPS	Coordinating Group on Alien Pest Species
COE	Corps of Engineers
DoD	Department of Defense
DLNR	Department of Land and Natural Resources (Hawaii)
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
ESMP	Endangered Species Management Plan
ESTCP	Environmental Security Technology Certification Program
GIS	Geographic Information System
INRMP	Integrated Natural Resources Management Plan
ISC	Invasive Species Council (each Hawaiian Island has one… e.g., Maui ISC)
Legacy	DoD Legacy Resource Management Program
MCBH	Marine Corps Base Hawaii
NBII	National Biological Information Infrastructure
NGO	Nongovernmental Organization
NIS	Non-Native Invasive Species
NOAA	National Oceanic and Atmospheric Administration
R&D	Research and Development
RIFA	Red Imported Fire Ant
SAR	Species-At-Risk
SERDP	Strategic Environmental Research and Development Program
SON	Statement of Need (SERDP)
TES	Threatened and Endangered Species
TER-S	Threatened, Endangered and At-Risk Species
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

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- Paul Banko, U.S. Geological Survey
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- Al Cofrancesco, U.S. Army Corps of Engineers
- Diane Drigot, U.S. Marine Corps
- Lu Eldredge, Bishop Museum
- Dan Friese, U.S. Air Force
- Lew Gorman, U.S. Fish and Wildlife Service
- Heidi Hirsh, U.S. Marine Corps
- Frank Howarth, Bishop Museum
- Flint Hughes, U.S. Forest Service
- Jim Jacobi, U.S. Geological Survey
- Gene Jones, CSU-Fullerton
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Finally, the sponsors wish to thank all of the event's participants (see Appendix A), as well as members of the TER-S Science Forum, who provided input on the workshop's scope and structure.

For more information on the TER-S Symposium and subsequent regional workshops, please visit www.serdp.org/tes, and click on the tab of interest.

1.0 INTRODUCTION AND BACKGROUND

This document presents a summary of results from the Pacific Islands Region TER-S Workshop sponsored by the Strategic Environmental Research and Development Program (SERDP), Environmental Security Technology Certification Program (ESTCP), and Legacy Resource Management Program (Legacy). The workshop took place 6-8 June 2006 at the Renaissance Ilikai Hotel in Honolulu, Hawaii.

The Department of Defense (DoD) utilizes nearly 30 million acres of land, and hundreds of square miles of air and sea space to conduct missions vital to National Security. These same lands, air, and sea space provide habitats for a great diversity of plants and animals, some of which are found only in areas within DoD stewardship. In fact, with approximately 320 threatened and endangered species and nearly 550 species at risk, the DoD harbors more such species per acre than any other federal agency. Although its mission is training military service personnel and testing weaponry, DoD is committed not only to protecting its lands, oceans, and airspace, but also the species that inhabit them. Through improved understanding of these species, their habitats, and relationships to military training and testing activities, DoD can work with stakeholders to enhance species conservation.

1.1 WORKSHOP SPONSORS

SERDP is DoD's corporate environmental research and development (R&D) program, planned and executed in full partnership with the Department of Energy and the Environmental Protection Agency, with participation by numerous other federal and non-federal organizations. DoD's environmental concerns may be viewed in terms of operation and/or cost impacts to its primary mission of maintaining military readiness for national defense. SERDP's Sustainable Infrastructure initiative supports R&D efforts to: 1) sustain the use of DoD's lands, estuaries, oceans, and air space; 2) protect its valuable natural, cultural, and built infrastructure resources for future generations; 3) comply with legal requirements; and 4) provide compatible multiple uses of its resources. Efforts funded under these categories are basic and applied research, and typically last for 3-5 years.

ESTCP is a DoD program that promotes the use of innovative, cost-effective environmental technologies at DoD sites. ESTCP's goal is to demonstrate and validate promising, innovative technologies that target DoD's most urgent environmental needs, including range sustainment. These technologies provide a return on investment through significant cost savings, improved efficiencies, and reduced environmental risks. Successful technologies supported by ESTCP often have commercial applicability.

Legacy provides DoD funding to efforts that conserve and protect our nation's natural and cultural heritage. The program assists DoD in protecting and enhancing resources while supporting military readiness. Three principles guide the Legacy Program: *stewardship*, *leadership*, and *partnership*. Stewardship initiatives assist DoD in safeguarding its irreplaceable resources for future generations. By embracing a leadership role as part of the program, DoD serves as a model for respectful use of natural and cultural resources. Through partnerships, Legacy strives to access the knowledge and talents of individuals outside of DoD. This is accomplished through the funding of management-oriented projects that support one or more of

the 12 areas of emphasis. The areas supported by Legacy include Readiness and Range Preservation, Cooperative Conservation, Invasive Species Control, and Regional Ecosystem Management.[1] Staff provides bimonthly updates on the Defense Environmental Network & Information eXchange (DENIX, www.denix.osd.mil).

Through the conservation aspects of the three programs, SERDP, ESTCP, and Legacy help DoD maintain its dual missions of readiness and environmental stewardship. R&D initiatives begun in SERDP may need to be validated through ESTCP and later implemented via Legacy. Likewise, on-the-ground management funded by Legacy may uncover basic R&D needs for future investment through SERDP and ESTCP. Ultimately, the three programs offer an integrative method of utilizing DoD funding to foster better natural resource management.

1.2 SCIENCE FORUM

The Endangered Species Roundtable is a group of Washington, DC-based policy makers, managers, and others who meet regularly to discuss relevant endangered species issues with a goal towards enhancing interagency cooperation. A working group of this body, the Science Forum, focuses specifically on related R&D needs and actions. Members of the Science Forum include representatives from U.S. Fish and Wildlife Service (USFWS), DoD, Army, Navy, Air Force, and Marines, as well as the Forest Service (FS), Bureau of Land Management (BLM), and National Park Service (NPS). This group provided input to the workshop charge, and offered suggestions for steering committee members and workshop participants. As agency representatives, four Science Forum members participated in the workshop

1.3 JUNE 2005 SYMPOSIUM AND WORKSHOP ON TER-S ON DOD AND ADJACENT LANDS

In June 2005, the U.S. Army Corps of Engineers (COE) Engineer Research and Development Center (ERDC), SERDP, Legacy, and other federal and non-federal partners sponsored a national symposium to examine issues related to TER-S on DoD and adjacent lands. The objectives were to:

- present the most up-to-date information on government and academic TER-S research relevant to DoD,
- stimulate collaboration and foster partnerships among participants, and
- identify additional areas of research needed to address TER-S and associated habitat issues facing DoD and other federal land-managing agencies.

Participants included nearly 200 researchers and managers from DoD, all the military services, the USFWS, NPS, U.S. Geological Survey, U.S. Department of Agriculture, and various non-profit organizations, state agencies, universities, and private consulting firms. Findings from this event are described in a proceedings document, available at: http://www.serdp.org/tes/National/.

The following needs were specifically identified as high priority:

[1] See www.dodlegacy.org *for more information on the Areas of Emphasis.*

- **Research basic species life history and improve biological information.** There is a serious lack of basic biological information for many listed and at-risk plant and animal species. Only through a clear understanding of the species and the stressors that directly impact population health and viability can suitable management protocols be developed.
- **Increase proactive conservation efforts for species at risk.** When considering the threats to already listed and at-risk species, it is evident that additional resources must be focused on proactive conservation measures to prevent additional species listings. Research is needed to properly and fully evaluate the cost-benefits associated with proactive (versus reactive) conservation efforts, especially with respect to the impacts of non-native invasive species. Knowledge gained could then be used to implement appropriate policies and funding initiatives that would conserve resources in the long-term.
- **Develop more consistent peer-reviewed data standards and monitoring protocols.** Monitoring protocols, guidelines, and indicators are not fully developed for many TER-S. Additionally, in cases where protocols exist, they do not necessarily provide meaningful data for decision makers. Therefore, research is needed to develop protocols. This must be done using a rigorous scientific approach and peer review process that incorporate how data are to be collected, managed, analyzed, and reported to ensure efficient collection of data elements directly relevant to key management decisions.
- **Improve predictive models to support management decisions.** To manage and conserve TER-S habitat at a regional scale, land managers must apply a complex suite of management measures across a wide landscape in coordination with other regional landowners to achieve ecosystem goals. While several pilot projects have been completed, additional research is needed to refine, validate, and expand these predictive modeling efforts.
- **Improve information-sharing among stakeholders.** Funds available for monitoring and conserving listed species are limited, with no one organization having the ability to collect all of the necessary data or to fully implement regional conservation restoration measures. It is important to be able to leverage conservation-related information and actions across agencies and in partnership with private initiatives. Through the development and application of new technologies based on significant collaboration, it may be possible for TER-S conservation organizations and partners to yield significantly enhanced results.
- **Focus on protection of endangered ecosystems rather than individual species.** 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 single species. Research is needed to develop more sophisticated regional management tools and approaches.

Further, it was determined that TER-S issues are fundamentally regional in nature. For example, the decline of Pacific salmon is no more an issue in Illinois than the decline of the gopher tortoise is in New Jersey. In response, and to help further refine and implement the 2005

symposium results, SERDP, ESTCP, and Legacy developed a plan to host a series of regional TER-S workshops.

Symposium participants specifically identified the need for workshops in the following four regions: Pacific Islands, Southeast, Southwest, and Northwest.[2] Boundaries for the four identified regions were to be determined by location of military installation and key ecological features, rather than on existing but artificial agency boundary determinations.

By overwhelming consensus, it was decided that the first regional workshop should take place in the Pacific Islands region, as this region was considered to be most at-risk of having additional species listed or, for those species already listed, go extinct in the relatively near future. Appendix B captures participant input.

1.4 PACIFIC ISLANDS REGION

There may be as many life zones in the Hawaii Volcanoes National Park alone as there are in the entire United States, as well as in all of Brazil. The Hawaiian Islands as a whole boast more than 15 military installations and ranges encompassing over 200,000 acres of land, and supporting least 100 threatened or endangered species (approximately 1/3 of the total TER-S in Hawaii). Significantly, many of these populations exist nowhere else in the world and have less than 50 individuals. Current threats to TER-S in Hawaii and elsewhere in the Pacific region (e.g., Guam and elsewhere in the Marianas), include the prolific spread of invasive species, encroachment, climate change, and military training (see Appendix C for maps of DoD holdings in the region).

DoD has a vested interest in maintaining training capabilities throughout this region. With the implementation of the 2005 Base Realignment and Closure (BRAC) action plan,[3] the military footprint in the Pacific Islands region will increase significantly. This will be especially true on Guam, but also in Hawaii (Oahu and the Big Island). Because the region has the highest number of TER-S in the United States, the challenge for DoD is to determine how to effectively use the available land and water resources for National Security missions while simultaneously conserving species protected by the Endangered Species Act and those at-risk of needing such protection.

SERDP, ESTCP, and Legacy can help address this challenge by targeting their program dollars towards conservation efforts that achieve species and habitat protection goals while maximizing training and testing flexibility. Working together, these three programs strive to tackle conservation challenges holistically and proactively. By removing the threats that impair at-risk species, recovering listed species, and managing using an adaptive and ecosystem-based approach that considers ecological processes as well as multiple spatial and temporal scales, DoD's conservation programs strive to keep common species common while preventing the need for additional species listings.

[2] A workshop in the Northeast region was not deemed necessary because the military does not have significant TER-S issues in that part of the country.
[3] See http://www.dod.mil/brac/ for more information on BRAC 2005.

2.0 APPROACH

The stated objectives for the Pacific Islands Region TER-S Workshop were to:

- identify TER-S management needs among the Pacific Islands,
- examine the current state of practice within DoD for regional TER-S management,
- identify the gaps in knowledge, technology, and management that limit both the transition of emerging technologies and the implementation or development of new approaches, and
- prioritize investment opportunities to address these gaps.

2.1 WORKSHOP CHARGE AND PRE-WORKSHOP QUESTIONNAIRE

Because SERDP, ESTCP, and Legacy have supported relatively few projects in the Pacific Region, and because island TER-S issues are unique and often distinct from mainland issues, organizers decided that the best approach for developing a workshop agenda was to solicit input from the researchers and managers who know the regional issues best. Towards that end, the sponsors created a pre-workshop questionnaire designed to elicit the top TER-S issues in the region (see Appendix D). Generally, the questionnaire asked for input and opinions regarding the key research, policy, management, and coordination gaps and needs, as well as input regarding future land management/land use issues.

Prior to the workshop, invitees received a one-page workshop charge (see Appendix E), and were asked to complete the questionnaire. Even if invitees declined the invitation, they were asked to take a few moments to provide feedback to the questions. Of the 55 invitees, 19 provided responses. Using information contained in completed questionnaires, a matrix of responses was created that captured ideas and comments common to multiple respondents (see Appendix F**)**. This matrix was then used as the basis for developing a draft workshop agenda. To help ensure topical relevancy, this straw man agenda was provided to the Science Forum and to workshop steering committee members for further refinement.

2.2 STEERING COMMITTEE

Formal invitations were extended to representatives from the various sectors of the endangered species management and research communities, including federal, state, and NGO representatives from the Pacific and Washington, DC regions. The committee's purpose was to act as an information source and guiding force for agenda development. Specifically, members were asked to identify potential white paper authors and topics, as well as speakers and chairpersons, and to define relevant breakout session topics.

For a variety of reasons, the success of this steering committee was limited. First, university invitees declined to participate due to academic conflicts. Second, several local and regional representatives who agreed to participate, did not. The result was a disproportionate number of

DC-based and military service participants. Nevertheless, contributions from the regional personnel who were able to fully engage in the planning process proved invaluable.

2.3 READ AHEAD MATERIALS

Outcomes from this workshop will be used to identify TER-S related research, demonstration, and management funding recommendations for SERDP, ESTCP, and Legacy, as well as for other interested parties, over the next three to five years. To prepare participants for the workshop, various read-ahead materials were provided as "thought stimulators." These included general information about military natural resource activities in the region, information about the sponsoring agencies, and a workshop charge (Appendix E) that describes the event's goals and objectives.

Additionally, two weeks prior to the workshop, session chairs were provided charges specific to their respective sessions. When reviewing these, they were 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 creating partnerships to manage species across jurisdictional boundaries, and the public's perception of DoD's mission and its impact on TES (see Appendix G for session charges).

2.4 PARTICIPANTS

The sponsors wanted to ensure that participants represented a diverse group of knowledgeable discipline experts who could provide the broad technical basis for what would become the DoD out-year research, demonstration, and management agenda for TER-S conservation in the Pacific Island region. In addition to inviting local and headquarters-level representatives from all of the military services, the sponsors also invited a balance of federal and non-federal field managers, academic researchers, Hawaii State natural resource personnel from both the aquatic and terrestrial divisions, and representatives from various local conservation organizations. In the end, 63 individuals participated in the workshop.

2.5 AGENDA ELEMENTS

Organizers wanted to ensure that participants received input from principal relevant stakeholders, including the State, NGO, and military communities. Further, they felt presenting background papers highlighting the state-of-the-science for both the aquatic and terrestrial systems was important. Finally, the sponsors believed that attendees needed to see first-hand how the military manages its dual missions of natural resource conservation and military training and testing.

With these considerations in mind, the first day of the workshop was designed to accommodate speakers from the State, NGO, and military communities with presentations regarding the region's aquatic and terrestrial systems and a field tour of Marine Corps Base Hawaii (MCBH) at Kaneohe.[4] The following two days included a series of breakout sessions, which concluded on Thursday afternoon with two synthesis sessions (one aquatic and one terrestrial) in which

[4] Due to a scheduling conflict, Major General Lee was unable to provide his address on Tuesday. He graciously fulfilled his commitment by coming later in the week.

participants reviewed, refined, and prioritized information garnered over the previous two days. Following the formal workshop, session chairs, speakers, and organizers met to discuss the overall context of the workshop and proposed recommendations.

2.6 FORMATION OF BREAKOUT GROUPS

The primary objective for this workshop was to develop a prioritized research agenda and management agenda for TER-S in the Pacific Islands region. Participants were asked to discuss the state of the science for endangered species research as a basis for determining gaps in current scientific knowledge, identify and roughly prioritize research needs, and develop the initial design for a research and management agenda for Pacific Islands endangered species. To do this, attendees participated in four of the twelve topical sessions and one of the two synthesis sessions.

Topic area	Breakout group 1	Breakout group 2	Breakout group 3
Individual Species Approaches	Aquatic TER-S (freshwater and marine)	Plant TER-S	Animal TER-S
Ecosystem Management	Dry Forests/Grasslands	Wet Forests	Coastal/Riparian/Wetlands
Impacts of NIS on TER-S	Aquatic Invasives	Non-native Invasive Plants	Non-native Invasive Animals
Synthesis	Terrestrial Issues	Aquatic Issues	
Technology Transfer	Information Sharing	Coordinating Management Activities	Building Partnerships and Outreach Opportunities

Each of the five breakout sessions began with an introductory presentation to all workshop participants. After the introductory presentations, workshop participants separated into assigned breakout groups.

3.0 ESTABLISHING A COMMON GROUND

The primary focus for this workshop was to elicit information regarding the current state of science, gaps in research and management, and future directions for improving conservation of Pacific Islands TER-S in ways compatible with the military training and testing mission.

The first day of the workshop was devoted to providing attendees with background and contextual information. The workshop began with introductions and program summaries by Dr. John A. Hall, SERDP/ESTCP, and Mr. L. Peter Boice, DoD Conservation/Legacy. Dr. Hall and Mr. Boice also detailed the workshop's goals and expected outcomes (see Section 5.0 for summaries).

Plenary presentations clarified the current state of TER-S in the region from a variety of perspectives, and helped set the stage for the breakout group discussions to follow. In the afternoon, 30 workshop participants boarded buses for a field tour of MCBH at Kaneohe that highlighted challenges faced by the military and provided examples of highly successful on-the-ground TER-S conservation projects. The remainder of the workshop, which took place over the next two days, consisted of five breakout sessions designed to address key issues relevant to Pacific Islands TER-S.

3.1 PLENARY SESSION

In developing the format for this workshop, the sponsors felt it was important to capture the different perspectives affecting the military's management of TER-S in the region. For endangered species management, the three main organizational forces are the State, NGOs, and the military. Organizers therefore solicited the participation of Hawaii's Department of Land and Natural Resources (DLNR); the Bishop Museum, a leading research and management organization in the region; and the Army National Guard, which has the lead for the military in the region and whose activities dominate military land use in Hawaii.

Mr. Peter Young, Director, Hawaii Department of Land and Natural Resources

The opening speaker was Mr. Peter Young. His charge was to provide a welcome from the State of Hawaii; discuss the State's interests and perspectives in managing listed, at-risk, and invasive species; and touch on the State's major initiatives in these areas, including the State's new comprehensive wildlife management strategy.

Mr. Young began by providing an overview of State TER-S, stating that Hawaii has the dubious distinction of being the endangered species capital of the world, leading the nation with 317 federally listed species—3 mammals, 32 birds, 4 reptiles, 5 invertebrates, and 273 plants. With only 0.2% of the land area, this means that Hawaii contains more endangered species per square mile than any other place on Earth. Similarly, nearly 75% of the nation's historically documented plant and bird extinctions have occurred in Hawaii.

In their formative years, myriad species arrived and colonized the Islands. Seeds, spores, and insects were blown in by the wind or carried in by birds, while seeds, larval forms of fish, invertebrates, and algae washed in with the tides. It is estimated that one plant or animal arrived

and successfully colonized in the area every 30,000 years. Over millions of years in isolation, these original plant and animal species evolved, forming the Islands' native species. The first non-native species arrived with Polynesians around the year 300 A.D., and introductions increased in 1778, when Hawaii was placed on the world map. Since then, as many as 10,000 plants, 343 marine/brackish water species, 40 reptiles, 6 amphibians, and tens of thousands of insects have been accidentally and intentionally introduced.

In 2005, to manage TER-S and NIS effectively, the State collaboratively developed a Comprehensive Wildlife Conservation Strategy that encompasses native terrestrial and endemic aquatic species, including flora, and native habitats from mountains to the sea.[5] The Strategy provides objectives at multiple landscape levels, including state, island, marine, and species. Statewide conservation objectives include:

- Protect and restore native habitats and species
- Combat invasive species
- Improve data collection and management
- Strengthen existing and create new partnerships and cooperative efforts
- Increase education and outreach
- Support policy changes to aid conservation
- Enhance funding to implement conservation actions and enforcement

Implementation of these objectives can be achieved only through multiple agency and organization partnerships, including with DoD.

Integrated Natural Resources Management Plans (INRMPs) and Endangered Species Management Plans (ESMPs) are plans that DoD installations develop to help military natural resource personnel manage their programs in a coordinated, comprehensive, and goal-oriented way. By cross-referencing INRMPs and ESMPs with the State Comprehensive Wildlife Conservation Strategy, the Hawaii DLNR can more holistically ascertain species and system health, and better manage for long-term conservation goals, for example by leveraging monitoring data in support of adaptive management. A formal revision of the State's plan will be undertaken in 2015.

In the Hawaiian Islands, land mass represents a closely knit network of disparate and sometimes overlapping watersheds. Watershed partnerships that unite diverse partners toward a common goal of protecting and managing large landscapes are thus a key management tool. Hawaii is the national leader in developing landscape-scale cooperative partnerships among private, county, State, and federal entities to protect and manage forests for multiple benefits, such as water recharge, forest preservation, and habitat and species protection. DLNR provided the initiative and principal support for establishment of Statewide watershed partnerships, and successfully leveraged State dollars to obtain federal and private competitive grants. Approximately 1 million acres, about 25% of the State, is enrolled in watershed partnerships.

[5] See http://www.state.hi.us/dlnr/cwcs/process_strategy.htm.

Other examples of management tools for TER-S highlighted by Mr. Young included a habitat conservation plan for the native red ilima plant, habitat restoration for the palila, and safe harbor agreements for the Hawaiian stilt, Hawaiian coot, and the nene—all of which are highly endangered and exist only in the Islands.

Arguably, the most significant threat to the survival of many of Hawaii's TER-S is the rapid spread of invasive species. Addressing this threat is the State's highest priority. Invasive species impact tourism and agriculture, the forests' ability to channel rainwater into the watershed, survival of native species, resident and visitor health, and general quality of life. The Hawaii Invasive Species Council includes members from numerous State departments and organizations and, together with the island invasive species committees, provides the institutional framework for leadership and coordination of a statewide invasive species program, encompassing prevention, response and control, targeted research, and outreach.[6]

For 2007, the total funding for invasive species control is $6.43 million. Invasive species of special concern include *Miconia calvescens*, which affects wet forests; brown tree snakes (BTS), which have decimated bird populations in Guam; West Nile virus, which also disproportionately affects birds; invasive grasses, which increase fuel loads and frequency of wildland fire; and invasive seaweeds, which are devastating native corals and other sea life. Hawaii was one of the first states to adopt and implement the 2003 Aquatic Invasive Species Management Plan.[7]

Mr. Young closed by highlighting several DoD partnerships in support of TER-S, including conservation of rare plants at the Army's Makua Military Reservation, transfer of Kaho'olawe from the Navy to the State for conservation purposes, BTS monitoring at Andersen Air Force Base, Marine Corps tracking of Nu'upia Ponds to preserve endangered bird species, Coast Guard removal of marine debris in the Northwestern Hawaiian Islands, and National Guard receipt of environmental awards. Relevant to the workshop's objectives, he emphasized the need for targeted research that informs field management activities.

Dr. William Brown, Director of the Bishop Museum

Representing one of the Island's premier scientific research and outreach NGOs, Dr. Brown was asked to provide an overview of the Bishop Museum's interests, perspective, and activities regarding listed and at-risk species in the Islands, and what the NGO and broader research community can offer, organizationally, in terms of knowledge and ongoing research.

Founded in 1889, the Bishop Museum is the largest non-profit research institution in the Pacific region, with campuses in Kalihi, the Hawaiian Maritime Center, and the Amy Greenwell Garden. Its mission is to study, preserve, and tell the stories of Hawaii and Pacific region cultures and natural history. Bishop boasts over 250 employees with an annual budget of $16 million.

Dr. Brown began by describing several ongoing Bishop initiatives relating to cultural collections, anthropological investigations, library and archival resources, and natural resources. For example, Bishop houses both the Hawaii and Pacific biological surveys, the purpose of which is

[6] Each Hawaiian island has its own invasive species council (e.g., Maui ISC, Kauai ISC).
[7] See http://www.hawaii.gov/dlnr/dar/pubs/ais_mgmt_plan_final.pdf.

to "advance the knowledge and understanding of the biological diversity of Hawaii and the Pacific region." Bishop's biological collection contains approximately 21.1 million specimens. Currently, Dr. Brown explained, Bishop supports over 300 marine, terrestrial, and freshwater habitat expeditions, with field work occurring in all the island groups and on all major islands. Biological surveys in Hawaii encompass offshore islets, terrestrial and freshwater areas, and all significant Hawaiian Islands marine areas. In the greater Pacific region, Bishop is conducting biological surveys in New Guinea and Fiji and an insect survey in French Polynesia. These surveys are helping to identify TER-S and determine their status throughout the region. For example, in New Guinea scientists from the Bishop Museum – funded by the National Science Foundation – have discovered more than 120 new species of amphibians and reptiles, and hundreds of species of insects important to global biodiversity.

Another important study for native Hawaiian ecosystems and their associated TER-S is occurring in Waipi'o Valley on the Big Island of Hawaii. This project involves comparative studies of two Valley streams, and a full-scale effort to restore native stream water flow, considered critical to the survival of several endemic and imperiled stream fish and insects.

Dr. Brown concluded by describing the Pacific Center for Molecular Biodiversity, where scientists are working on the molecular identification of reef fishes to contribute data to the Barcode of Life project.[8] The project's goal is to collect, manage, analyze, and use molecular level species information so that scientists can more easily and accurately identify species, determine population genetic variability and viability, and possibly manage TER-S more efficiently.

Major General Lee, **Adjutant General, Hawaii Army National Guard**

Given that this workshop was specifically geared towards addressing TER-S of interest to the DoD, it was important for participants to hear the military's perspective. General Lee gave an insightful presentation on the military's perspective of TER-S in the Hawaiian Islands, opening with an explanation of his State and federal missions for the Hawaii Army National Guard.

As the State's Adjutant General, Major General Lee is director of a diverse organization which encompasses both the Hawaii Army and Air National Guards; the State Civil Defense; the State's Office of Veterans Services; and the Youth Challenge Academy, a residential mentorship program for at-risk youths. In addition, he acts as the Governor's advisor on Homeland Security issues.

Major General Lee stated that new stationing requirements include approximately 5,500 Army and Air National Guard troops that live on and move through the Hawaiian Islands for training and readiness missions. With the implementation of BRAC plans for Hawaii National Guard, Major General Lee will see his responsibilities increase. After a brief overview of planned Pacific troop realignment in the region, General Lee discussed the probable impacts of realignment, and how that will affect both TER-S monitoring and management, and responses to national disasters.

[8] See www.barcodinglife.org for more information.

Under his jurisdiction or use by the National Guard are several training areas that include a myriad of threatened and endangered species. These areas include Ukumehame Range, Pohakuloa Training Area, Diamond Head, Keaukaha Military Reservation, and Hickam Air Force Base. He explained the Guard's plans for avoiding endangered species and their habitats, and how training does and does not affect species survival. For example, he explained, at Ukumehame Range on Maui, the Guard schedules firing times to avoid interfering with Néné or Hawaiian Goose (*Branta sandvicensis*) and Hawaiian Stilt (*Himantopus mexicanus knudseni*) breeding, and move the birds off the ranges to avoid incidental take. General Lee also explained the frequency of training on that area, and how little troop activities actually impact bird colonies.

Another example he highlighted was the patrolling of facilities at Diamond Head Crater. While active training does not occur at this facility, the DoD is still responsible for patrolling the area to make sure there is no harassment of the flowering plant Ma oli oli (*Schiedea kealiae*). General Lee also described the Guard's "don't feed the cats" initiative that he instituted to help reduce the number of feral cats that prey upon endangered birds.

Although not done to benefit TER-S, General Lee has also undertaken a project to inspect all Island dams. With the recent flooding in the Hawaiian Islands, it became apparent that several dams were unsafe and in need of immediate repair. Under General Lee's control, several of these dams have either been removed, thereby allowing the return of natural stream flows that is important for endemic fish and insect survival, or repaired, which has beneficial downstream effects by trapping sediment and protecting wetlands.

In closing, General Lee explained that while his primary mission is to make sure troops are safe and ready for their missions, he also must protect the endangered and at-risk species that reside within his jurisdiction.

3.2 CONTEXTUAL INFORMATION

To complement the plenary presentations, researchers from the University of Hawaii and Bishop Museum described the state of the science in aquatic and terrestrial ecosystems.

Dr. David Duffy, University of Hawaii (UH)

Dr. David Duffy is Chair of the Department of Botany at UH and Director of the Pacific Cooperative Studies Unit (PCSU), a cooperative effort between the University of Hawai'i, U.S. Geological Survey, and National Park Service.

Dr. Duffy began by outlining improvements that are needed to support TER-S conservation in Hawaii. Despite significant financial and human resources, he explained, Hawaii remains in a conservation crisis. The present status of native species in Hawaii is not good (Table 1), and downward trends continue to persist (e.g., number of surviving endemic birds). Although not included in Table 1, invertebrates have suffered a 10% loss over the last 150 years. Declines of native species are due to habitat loss (prehistoric and post-contact), human exploitation, invasive species (mainly Polynesian and European), and disease and pests. Presently, native plants and birds are particularly vulnerable.

Current Hawaiian conservation science largely involves exclosure of ungulates, eradication of rats and cats, horticulture of rare plants for outplanting, and natural history research. To address the conservation crisis for TER-S, and to keep common species common throughout the Pacific Islands region, Dr. Duffy argued that the following issues must be addressed:

- *Managing without scientific knowledge* – There is a need for scientific development and evaluation of "best practices," such as optimal site selection, best age to outplant, how long to care, and review of reintroduction survivorship. There is also a need to collect baseline quantitative data about managed species (e.g., basic life history).
- *Little or no modeling-based research agenda* – For endangered species recovery, managers must know: 1) how many individuals remain, 2) how many individuals are necessary for long-term survivorship, 3) optimal habitat and carrying capacities, 4) extent of optimal habitat, and 5) if habitat is insufficient, how to restore suboptimal habitat.
- *Poor planning* – Most plans do not have measurable outcomes (i.e., metrics), resources for implementation, or specific, prioritized management actions.
- *Poor logistics* – Logistical issues, such as training, leadership, safety, and permitting, have derailed conservation programs in the past.
- *Little or no operational overview* – Restoration too often has tactical rather than strategic goals. There is a need for scientists to interact with managers to provide useful feedback and assessments using adaptive management strategies.
- *Institutional problems* – Numerous institutional issues can have a detrimental effect on knowledge acquisition and sharing, such as xenophobia or agency turf, failure of scientists to publish, lack of relevant university courses, and a culture of consensus building.
- *Funding* – There is a need to better link actions to results to stimulate project funding streams (e.g., $X million buys N species off the endangered species list). Funding decisions often are based on emotion rather than strategy (e.g., coqui).

Solutions, Dr. Duffy continued, do exist and can be achieved through local-level partnerships which he said are essential to managing TER-S. Specific to the PCSU is the potential for additional collaboration with The Nature Conservancy (TNC), Bishop Museum, and others to further leverage resources and information. Cross-agency and cross-discipline communication of issues, studies, and results also is critical. Stanford University provides an excellent forum for such discussions twice per year as part of its experimental forest on the Big Island.

Table 2. Present Status of Native Species in Hawaii

Taxon	Total Number of Species	Percentage of Species at Risk*	Number of Extinct Species
Flowering Plants	1,153	30	106
Mollusks	1,267	Less than .01**	800-900
Birds	71	44	82
Mammals	2	100	1

* Threatened or endangered
** Species are largely extinct

Dr. Lu Eldredge, Bishop Museum

Dr. Lu Eldredge, Invertebrate Zoologist at the Bishop Museum, focused his talk on the threat posed by non-native invaders in aquatic systems in the Pacific Islands. He began his presentation by defining non-native species and invasive species, emphasizing the differences between the two, and criteria for their determination.[9] He then went on to discuss several intentional and accidental pathways of non-native species introduction into the Hawaiian Islands, giving examples of the most aggressive NIS in the local freshwater and marine environments.

Quoting figures from an ongoing marine non-native invasive species (NIS) survey being conducted by the Bishop Museum in the tropical Pacific, Dr. Eldredge stated that, in total, there are more than 300 non-native marine species in the area. Of these, more than 21% originate from elsewhere in the Pacific. The most extensive group of marine invaders is invertebrates, which are having a disproportionate impact on coral reef health.

Several species of macroalgae have also invaded the region, affecting not only coral reefs, but also near shore areas, resulting in significant health and economic impacts. According to Dr. Eldredge, the most important vector for introducing these species is through the aquaculture industry. In addition to their impact on and threat to native species, these invaders have cost thousands of dollars to clean up. By way of example, Dr. Eldredge noted that the cost to clean up one invasive algae, *Hypnea musciformis*, in Hawaii is more than $100,000 per year and involves removing 20,000 pounds that wash up on Maui shores every year. An economic impact study of the north coast of Kihei (one of Maui's more popular beaches) concluded that losses due to the invasion of this one algae – including loss in rental income due to algal wash up, decrease in property values, and actual cleanup – are more than $20 million dollars annually.

To deal with these types of problems, many agencies have begun to form partnerships to help curb the effects of these invaders. One such partnership has targeted the invasive algae *Gracillaria salicornia*. In collaboration, partners have conducted several cleanup efforts and designed informational brochures to improve public awareness.

Dr. Eldredge next described pathways for aquatic invader introduction, particularly unintentional ones, such as through shipping traffic. Throughout the world, the most common vectors for transporting non-native species are hull fouling, and solid and liquid ballast.[10] According to a

[9] Invasive species are a subset of non-native species, with approximately 10% of non-native species developing invasive characteristics, such as rapid and hard-to-control growth or spread.
[10] See http://darwin.nap.edu/books/0309055377/html/22.html for more information on ballast.

recent study, of the 212 species introduced by hull fouling in the shipping industry, 90% have become established and are threatening native TER-S Hawaiian ecosystems. This is of relevance to DoD because of the increased ship traffic anticipated from the upcoming Pacific corridor realignment.

Furthermore, Dr. Eldredge introduced the group to a Web-based checklist of marine invertebrates in the Hawaiian Islands.[11] On this Bishop Museum site, the public can browse, search, and access species descriptions of both native and non-native marine invertebrates throughout the Hawaiian archipelago. There is also an online checklist pin-pointing all of the Bishop Museum's survey sites, complete with a GIS map of all sampling areas.

In conclusion, Dr. Eldredge again emphasized the importance of aquatic NIS and the threat these species pose to the integrity of native Hawaiian ecosystems in general, and to TER-S habitats in particular.

3.3 FIELD TOUR OF MARINE CORPS BASE HAWAII

Marine Corps Base Hawaii (MCBH) practices "Basewide Environmental Management System Integration and Sustainability" (EO 13148) and is the first U.S. Marine Corps (USMC) base to fully meet all DoD and USMC implementation criteria as specified in Executive Order 13148, *Greening the Environment Through Environmental Management*. According to Dr. Diane Drigot, MCBH Natural Resource Manager, MCBH's environmental program mission is to "carry out the functions of compliance, pollution prevention, conservation, installation restoration, and training, education, and outreach at MCBH such that we contribute to the combat readiness of our Marines, and protect human health and the environment."

Alex Beehler joins the workshop attendees who participated in a tour of MCBH.
Photo by Ensign Marc Tinaz, USN

Installation personnel strive to implement this mission in all facets of environmental management. The success of their efforts has resulted in the environmental staff being awarded the Natural Resource Conservation Meritorious Achievement Award from the Secretary of Defense (2001), the Natural Resource Conservation Meritorious Achievement and Environmental Quality Meritorious Achievement awards from the Secretary of Defense (2003), and the Natural Resource Conservation and Environmental Quality awards from the Secretary of the Navy (2003).

In order to better understand TER-S management and conservation on DoD lands in the Pacific Islands, 30 workshop participants spent the afternoon of the workshop's first day touring MCBH. While many participants were familiar with the MCBH and Kaneohe Bay, others were not. Similarly, many of the participants

[11] http://www2.bishopmuseum.org/HBS/invert/list_home.htm.

were unfamiliar with the requirements of military operations and the constraints that endangered species management can place upon those operations. Dr. Diane Drigot, the installation's Senior Natural Resources Management Specialist, selected five locations of interest and provided on-site presentations at each.

3.3.1 Red-Footed Booby Colony

MCBH Ulupa'u Crater supports vital combat weapons training, along with 2,500 federally protected red-footed boobies. A primary risk to both is brushfires fueled by invasive grasses within the impact area that, unchecked, could result in declines in imperiled wildlife populations, significant erosion, and loss of training time. Through several grants and in-house funding efforts, staff at MCBH has installed a field-based sprinkler system that substantially reduces the risk of fire thereby securing range operations, fire response, and bird habitat.

Red-footed boobies at the Ulupa'u Crater Weapons Range and Red-Footed Booby Colony, MCBH.
Photo by L. Peter Boice

3.3.2 Wetland Creation Site

In an area draining stormwater runoff from a combat vehicle maintenance compound toward Nu'upia ponds, Dr. Drigot's team successfully carried out a project to replace a dysfunctional, weed-choked drainage ditch with a constructed wetland lined with native plants. Not only has this project implemented Environmental Protection Agency (EPA)-recommended best management practices (BMPs) for stormwater management, it has also helped to create and maintain valuable TER-S habitat for several native endangered bird species.

3.3.3 Stream Corridor Restoration Site

Along Marine Corps Training Area Bellows' (MCTAB) Waimanalo stream corridor, Marine combat service support unit engineers removed invasive vegetation to reduce flood risk while enhancing operator skills in deploying BMPs to minimize erosion effects. Three acres of invasive weed-choked "fill" land along the stream corridor were replaced with a meandering, terraced, native plant-lined "pocket" wetland to better contain floodwaters, filter stormwater runoff, restore historic habitat for native avian and aquatic life, and enhance scenery and a Hawaiian "sense of place." A more conventional flood control approach would have "hardened" streambanks and further degraded the stream corridor's scenic, wildlife, and water quality values.

3.3.4 Mud-Ops and Nu'upia Ponds

Nu'upia Ponds Wildlife Management Area (WMA) is a prime breeding ground for the endangered Hawaiian stilt, hosting 10% of the State's remaining population. To ensure continued breeding success in this area, marines conduct their annual, supervised assault amphibious vehicle (AAV) "mud ops" training just prior to the stilt's nesting season, thus removing weeds

from their wetland habitat while enhancing AAV operator skills. Not only is this site a notable example of how training operations can be used to enhance TER-S habitat, it also demonstrates how military personnel can protect valuable cultural resources through adaptive management.[12]

3.3.5 Waterfront Operations at Kane'ohe Bay

View from Waterfront Operation at Kane'ohe Bay.
Photo by Leslie Orzetti.

At this picturesque site, managed by the U.S. Navy, participants received an overview of the biodiversity, history, and management of Kane'ohe Bay. Since this is a heavily used recreational area, the Navy is currently enforcing a 500-yard marine security buffer zone not only for military navigation and training needs, but also in support of a cooperative program with the USFWS, State of Hawaii, NOAA Fisheries, and several community groups to help maintain marine habitat. Key elements of management include spill response and invasive species control programs.

[12] According to MCBH's Natural Resource Conservation Awards Package (https://www.denix.osd.mil/denix/Public/News/Earthday98/Awards/Smin/hawaii.html), Nu'upia Ponds were built by early Hawaiian settlers about 1,000 years ago as fishpond walls connecting the peninsula with Oahu. The fishpond complex on MCBH is an eligible National Historic Property.

4.0 INDIVIDUAL SPECIES APPROACHES BREAKOUT SESSION

Given the current regulatory framework, many TER-S are managed at the individual species level. Although the need to manage TER-S at the ecosystem level is widely accepted, there are - still many important questions that need to be addressed at the species level. In the Individual Species Approaches breakout session, groups divided into Aquatic TER-S (freshwater and marine), Plant TER-S, and Animal TER-S. The outcome objective was for participants to identify and prioritize research, demonstration, and management needs relevant to individual listed and at-risk species relevant to DoD in the Pacific Islands region.

4.1 INDIVIDUAL AQUATIC TER-S

Dr. Dan Polhemus, Hawaii DLNR—Division of Aquatic Resources, chaired the Individual Species Aquatic TER-S breakout group. The group was tasked with identifying those needs relevant to individual listed and at-risk species in both inland and near-shore aquatic environments. Because TER-S monitoring and management is continually impacted by both natural and anthropogenic stresses that can prevent or severely hamper successful recovery and protection efforts, the group felt it was important to specifically iterate the top aquatic threats in the region. These are:

- non-native invasive species
- global climate change and associated sea level rise
- the loss, fragmentation, and degradation of critical habitat
- ocean acidification

Many of these stresses can be attributed to a few primary sources, including development, point and non-point source pollution, erosion, training and mission activities, and the burning of fossil fuels.

With respect to research needs, the group identified several high-priority listed species with significant data gaps in the areas of basic biological and ecological surveys, geographical presence and absence, standard methods and protocols, and population viability information (see Table 2 under *Research*). Participants noted that an adequate definition of "population viability" is lacking for determining both species survivorship and resiliency, and concluded that additional research is needed as to whether these definitions should be developed for groups of species or individual species. In the interim, members agreed that population viability information should be obtained from USFWS recovery plans.

Another important aspect of TER-S management is the use of various tools (e.g., technologies, protocols) to remotely sense and monitor organisms and habitats. The group identified several tools that require additional research to be practical for TER-S monitoring and management. Examples of these tools include gap analyses for basic geographical, biological, and reproductive information; military plans to assess training activities, development and realignment issues; climate change models; demographic species models; threat analysis for impacts from NIS; genetic and molecular analysis tools to track species and determine genetic viability; and stronger communication within DoD and among State and federal agencies and NGOs.

Research

Geographic areas in need of basic biological and ecological information to determine TER-S existence or habitat viability include:

- Freshwater Streams
  - Kawailoa Training Area
  - MCTAB, Air Force Station Bellows, specifically the Waimanalo and Inoaloe streams
  - MCBH, especially the Waikane stream
  - Guam Naval Magazine streams
- Wet Cave Systems at Andersen AFB, Guam Naval Magazine, and Naval Computer and Telecommunications Station Guam (NCTS)
- Anchialine Pools at Kanaio Training Area

Table 3. Aquatic Species Needs

Species	Biological	Geographical	Protocols	Population Viability
Newell's Shearwater	◦	◦	◦	◦
Dark-Rumped Petrel	◦	◦	◦	◦
Hawaiian Damselflies	◦		◦	◦
All stony corals		◦		
Tridacta clams		◦		
Seahorses		◦		◦
Napolean Wrasse		◦		◦
Bumphead Parrotfish		◦		◦
Cocoanut Crab		◦		
Hawaiian Duck			◦	
Marianas and Hawaiian Moorhen			◦	
Hawaiian Stilt			◦	
Hawaiian Coot			◦	
Banded Petrel			◦	
Short Tailed Albatross			◦	
Humpback Whale				◦
Sperm Whale				◦
O'opu alamo'o				◦
Mariana moorhen				◦

Demonstration

- Remote sensing of aquatic systems (freshwater and marine)
  - Hyperspectral imagery, infrared technology, LIDAR, and LASER
- Tagging
  - Acoustic, radio, and satellite
- Acoustic monitoring
- Remotely operated vehicles (ROVs)- Robots

- Automated data loggers (auto gauging for stream flow)
- SONAR
- Artificial substrates (sampling and trapping)
- Remotely operated cameras

Management

Because the information exists in various management plans, group members did not articulate specific management tasks, and instead identified high priority at-risk and imperiled species for which management actions are most needed:

- Native gobiid fish 'O'opu nopili (*Sicyopterus stimpsoni*) and 'O'opu nakea (*Awaous guamensis*)
- Anchialine pond shrimp (*Metabetaeus lohena* and *Halocaridina rubra*)
- Freshwater limpet Hihiwai (*Neritina granosa*)
- Brachiopod *Lingula reevei*
- Stony corals of *Montipera* species
- Montane bog plant *Isoetes hawaiiensis*

4.2 INDIVIDUAL PLANT TER-S

Dr. Gene Jones, California State University, Fullerton, chaired the Plant TER-S breakout group, which discussed species' needs relevant to biological information, restoration, monitoring, and communication. With 273 federally listed plants just in the state of Hawaii, it was not possible for the group to identify all species-specific needs. The group largely focused on species needs at the system level.

It was suggested that to effectively manage TER-S plants, an atlas of species-specific information should be developed. This species atlas should include information on current and potential distribution, genetics, population size and dynamics, minimum population size needed, threats and ranking, known pollinators and seed dispersers and their status, and actions needed to address these threats. Complete species information is currently available for only a few species (e.g., silversword); yet collecting more robust data frequently requires significant expenditure of resources, and therefore should not be undertaken when few individuals remain. For species in the 10-100 individual range, however, all of this information is needed for successful management. Yet, managers are faced with making decisions with little to no biological information and need guidance for managing species without complete information. For example, outplantings often occur in locations where plants already exist, but those locations may not be optimal for reproduction—species simply may have survived there in the past.

Beyond the species level, additional information is needed at higher levels to impact species recovery across the landscape. Specifically, rhythms of ecosystems are not well understood. This knowledge gap makes it difficult to assess whether any of the existing reserves are large

enough to survive 100, 1,000, or 10,000 years. By looking at the contribution of DoD lands to recovery of species at the landscape level, management targets and actions can be identified both on and off the installation.

Prior to undertaking restoration efforts, there is a need to define expectations and assess strategies. For example, what type of community structure is desired through outplanting? What associates—pollinators, mycorhyzae, microclimate—are needed? What processes must be restored? How can non-native species contribute to these processes? What modifications are needed to overcome severe levels of degradation? How can the system be manipulated to allow native species to outcompete invasive species (e.g., amendments to decrease nutrient availability, canopies for shading, etc.)? How can a succession sequence be established so that species can recover without outplanting? How can a more natural system be encouraged to prevent non-endangered species from becoming endangered? Cross-discipline communication is necessary to address these questions.

Although potentially invaluable to field efforts, practitioner information on successful and failed approaches to outplantings often is anecdotal and needs to be quantified, measured, and replicated. For example, it may be best to first restore common species (i.e., establish matrix), then improve soil condition, and then to restore targeted rare plant(s). Seeds of native species not currently at risk generally are not available for these efforts; the collection and long-term storage of seeds for TER-S plants is ongoing nationally. Greater attention to common native species seeds may lead to the identification of fire-resistant plants for DoD lands. For recovery efforts, such as those at Kaho'olawe, large-scale production of seeds to create an onsite seed bank is critical. Genetic diversity also must be maintained for plants to withstand disease and pests.

In support of TER-S plant recovery, long-term control methods for established invasive species are needed—this is particularly true for fountain grass and other problematic grasses. These grasses are a major problem for DoD because they increase fuel loads for wildland fire, which can constrain operations and degrade the native dry and wet forests. Base housing and residential areas in surrounding communities also may be threatened by wildland fires. There is no form of mechanical control for fountain grass, and chemical control is not effective. Some biologists are looking for control agents in the grasses' native ranges; however, additional efforts are needed to develop biocontrol for invasive grasses. Bioengineering may be necessary. Beyond control, there is a need to develop strategies and plans for preventing future NIS introductions or expansion.

Monitoring efforts are critical to determining and understanding the long-term success of species recovery and restoration efforts. Unfortunately, long-term monitoring is difficult to fund on a project basis and its potential impact on management and restoration has not been adequately demonstrated or communicated. Beyond monitoring species for immediate protection needs, DoD is trying to transition from reactive management to thinking about the long-term goal of keeping common species common. Habitat within and beyond the unit boundary are targets for monitoring. Given ecological indicators and thresholds, land managers need practical guidance to use them on a large scale (e.g., research design, how many samples are needed, type 2 errors). Theoretical frameworks are lacking to identify foci at each scale. For example, the intensity of monitoring may differ depending on the management target. Remote monitoring technologies can assist DoD in monitoring more habitat more cost-efficiently.

Research

- Address species-specific gaps on current and potential distribution (i.e., ranges).
- Conduct population viability analysis (PVA) for at least one TER-S plant in support of better understanding the unique nature of viability issues for species that are naturally rare and for focusing future research priorities.
- Identify associated plants and animals for a suite of plant TER-S.
- Improve understanding of the rhythms of ecosystems—fire, kipuka formation, tree replacement, die backs, etc.
- Better understanding of the role of non-natives in future ecosystems (e.g., non-native pollinators may serve valuable functions for the ecosystem).
- Develop broader control methods for slugs and black twig borer.
- Better understanding of the conditions that affect grass to woody vegetation shift.
- Develop biocontrol for fountaingrass and other problematic grasses.
- Develop a process/framework for monitoring using indicators and thresholds.
- Develop tools to determine the contribution of DoD lands to recovery of species at the landscape level for identifying management targets and actions.
- Conduct inventory to determine plant species about which nothing is yet known.
- Additional research specifically is needed on lobelia, which has DoD relevance.
- Better understanding the potential impact of invasive pollinators the reproductive success of native plant species.

Demonstrations

- Apply remote sensing technology to monitor plants in inaccessible areas.
- Validate techniques for restoration of communities and processes.

Management

- For TER-S plants, compile an atlas of species-specific information on current and potential distribution, genetics, population size and dynamics, minimum population size needed, threats and ranking, known pollinators and seed dispersers and their status, and actions needed to address these threats.
- Collection and long-term storage of seeds for common native species, especially those associated with the dry forest in support of post-fire rehabilitation.
- Collect quantitative data on outplantings to identify lessons learned.

- Control factors limiting recovery of plant TER-S using a tiered approach (e.g., ungulates, competition from weeds, pests, and pollinators – including introduced pollinators).
- Identify lessons learned from intensive efforts to determine status and distribution of species and conduct monitoring at Makua Military Reservation.
- Assess effectiveness of efforts to conserve biodiversity at landscape scale.
- Availability of DoD funds for monitoring and surveys at the ecosystem level.

4.3 INDIVIDUAL ANIMAL TER-S

Dr. Paul Banko, U.S. Geological Survey, chaired the breakout group on TER-S animals. The outcome objective was for this session to identify needs relevant to individual listed and at-risk animal species. The group expressed that the highest need is to manage TER-S at the ecosystem level, though they realized that there are still many important questions that need to be answered at the species level. The prominent endangered invertebrate species that were mentioned were *Achatinella* snails, *Drosophila* flies, and a *Manduca* moth. However, it was acknowledged that vertebrates comprise most of the threatened or endangered species, and that these include a variety of sea birds, water birds, and forest birds, as well as a megapode, a swiftlet, a kingfisher, a rail, a tree-roosting bat, and a fruit bat.

Underscoring the value of managing at the ecosystem level, several issues were mentioned as in need of research, including diet studies for the ecology of many bird species; disease, particularly how cycles of disease affect elepaio populations; and identifying roost preferences and habitat use patterns for bat conservation (e.g., using radio telemetry). Although these and other specific ideas for research were considered useful, the group instead focused on identifying more general research themes relevant to TER-S conservation under the following general headings:

- Monitoring and detection
- Threat control
- Habitat restoration
- Reintroduction augmentation/success
- Basic species information
- Basic inventory of species on installations
- Population viability (i.e., knowledge of what is required for recovery)

Under the topic of "threats," military operations were identified in general, with several activities identified as posing specific threats. These included aircraft noise, both fixed wing (jets and propeller) and helicopter; bombing and blast noise; and helicopter rotor wash. Identified threat impacts included the spread of NIS, fire, dust, and erosion.

The group also introduced a method of study that might be applicable to DoD research and management in support of TER-S conservation. The method is called "management by research" and, as the name implies, it combines management with a more rigorous review and monitoring of outcomes. This may be especially applicable to Hawaii since many of the TER-S conservation practices have not yet been tested or proven. Management by research involves implementing

conservation action, based upon the best available ecological information, then following that action with monitoring, evaluating, reporting, and adapting management based on the results. It is, in effect, the application of an Adaptive Management Framework.

The group identified numerous specific research needs, as well as a few management and demonstration needs. To aid readability, research needs are subdivided topically.

Research

Monitoring and Detection

- Develop techniques to detect animals at low-density population levels.
- Explore new tools for detection/monitoring of TER-S and NIS, including dogs, acoustic devices, radio transmitters, and satellite/remote sensing.
- Develop tools to detect/monitor TER-S and NIS in inaccessible areas to collect basic species information and determine population viability (i.e., knowledge of what is required for recovery).

Threat Control

- Better understanding of the threats of the various elements of military operations on animal TER-S, including:
  - helicopter impacts on marine mammals
  - effect of military noise on bats and crows in Guam
  - impacts of bombing on seabird colonies (see also monitoring tools for seabirds)
  - effect of helicopter rotor wash on TER-S snails, invertebrates, and nesting birds
  - identify military equipment vectors of NIS introduction
  - effect of on-land training to marine mammals (especially from noise)
- Develop cost-effective pest control strategies and technologies for the multitude of species negatively affecting TER-S throughout the Pacific Islands, including for carnivorous snails, rodents, snakes, ants, cats, mongooses, ungulates, black twig borer, yellow jackets, and mosquitoes.
- Develop improved control methods for invasive plants, especially via biocontrol.
- Develop fire management methods.

Habitat Restoration

- Develop improved methods to monitor habitat restoration practices (e.g., is mamane forest restoration working?).
- Determine the constituents of an ecologically healthy and sustainable Pacific Island watershed.

- Develop ways to model interactions to predict consequences of management actions.

Reintroduction Augmentation

- Improve sanitation protocols to control disease on TER-S snails grown in the laboratory.
- Develop protocols for TER-S reintroductions including risk assessment, integration with habitat restoration, basic biological information about TER-S and the factors that limit their populations, threat control, monitoring techniques, and requirement to publish results and inform decision-makers.

Demonstrations

- Develop aerial broadcast practices for rodent and snake control.
- Testing and application of new techniques for ungulate control.

Management

- Complete basic inventories of species that occur on DoD installations.
- Identify and adopt improved, cost-effective species detection and monitoring methods for arthropods; snails; seabirds exposed to bombing and other training; non-colonial, tree-roosting bats (e.g., for Hawaiian hoary bats, a radio telemetry based detector system and information on roost preferences are needed).
- Provide better review and scrutiny of innovative conservation actions using "management by research," adaptive management, strategic management, and rigorous experiment.
- Improve people management, especially geocaching.[13]
- Prevent erosion and increase habitat restoration efforts.

[13] Geocaching is an outdoor treasure-hunting game. See http://en.wikipedia.org/wiki/Geocaching for more information.

5.0 ECOSYSTEM MANAGEMENT BREAKOUT SESSION

By protecting habitats and the integrity of ecological systems upon which listed species depend (rather than focusing on the species itself), land managers can better ensure the long-term sustainability of these species while protecting other species that depend on the same ecological systems. In the Ecosystem Management breakout session, groups divided into Dry Forest/Grassland, Wet Forest, and Coastal/Wetland/Riparian (limited to near-shore coastal issues) ecological systems. The outcome objective was for participants to identify needs relevant to multiple listed and at-risk species within an ecological system context.

Dr. Boone Kauffman, U.S. Forest Service—Institute of Pacific Islands Forestry, introduced this session with a presentation focused on the impacts of NIS in dry forest systems. He first provided an overview of the Institute of Pacific Islands Forestry, whose mission is to support restoration, silvilculture, and management of native Pacific Islands region forests for conservation, economic, and cultural values. The thrust of Dr. Kauffman's presentation was the need to understand how invasions of non-native species (both plant and animal) alter dry forest functions and how these forest systems can be restored.

Dr. Kauffman identified the increase of fire associated with grass and ungulate invasions as a major problem throughout the Pacific Islands region. He provided examples of research projects addressing the impacts of these threats and their consequences to the forest ecosystem. He further stated that the lack of public education about the value of restoration and the effects of NIS is a significant hurdle that must be overcome. This is particularly important because NIS invasions can occur in a three-tiered influence scheme, with an interconnectedness that can be highly complicated and difficult to tease apart.

In closing, Dr. Kauffman reiterated the overall workshop purpose by suggesting that DoD work to better understand what research and development are already ongoing in the Pacific Islands region under the direction of organizations such as the U.S. Forest Service, University of Hawaii, U.S. Geological Survey, and Bishop Museum. He then encouraged workshop participants to overcome information barriers to the restoration of Pacific Island forests, including:

- finding new approaches to overcome altered ecosystems created by NIS,
- understanding invasive species effects at landscape scales – including effects of invasive pollinators on native plant reproductive success,
- understanding which ecosystems are susceptible to NIS,
- developing ecological restoration techniques to diminish the fire/invasion NIS cycle, and
- learning how to manage resources in a time of rapid global change and globalization.

5.1 DRY FOREST/GRASSLAND SYSTEMS

Dr. James Jacobi, U.S. Geological Survey, chaired the Dry Forest/Grassland breakout group. The group's focus was that land managers can better ensure the long-term sustainability of

species by protecting habitat and the integrity of ecological systems upon which species depend. The outcome objective was to identify needs relevant to multiple listed and at-risk species in the dry forest/grassland ecological system.

The group first determined that a significant portion of DoD installations are comprised of dry forest and that fire is a major problem in these areas. The group noted that good vegetation maps exist for forest planning (showing that conditions range from pristine to highly disturbed), but higher resolution vegetation mapping is needed for fire control and management.

Fire and restoration were identified as the most important issues for consideration in management of the dry forest/grassland ecosystem. Other issues of concern include invasive invertebrates (slugs, black twig borers, gall wasps, ants, cycad scales), invasive vertebrates, invasive plants, caves, lack of inexpensive and effective inventory and monitoring tools, and land use outside DoD ownership.

The following research, demonstration, and management needs were specifically identified by major category to address these issues:

Fire

Research

- Develop ways to achieve post-fire revegetation, including emergency rehabilitation and rapid planting techniques. Of specific interest is determining what species are best suited for post-fire revegetation.
- Develop low ignition vegetation methods for use as firebreaks and other strategic placements (e.g., napaka and kukui tree).
- Develop more effective prescribed burning techniques.
- Explore the use of high resolution vegetation mapping. Consider the use of LIDAR and hyperspectral imaging to highlight carbon pools and above-ground fuels.
- Determine military munitions ignition sources and their associated probability of fire ignition.
- Improve understanding of fire behavior.
- Explore the use of grazing to control fuel loads.

Demonstration

- Validate fire behavior models for dry forest/grassland systems.
- Demonstrate/validate various new mapping techniques.
- Demonstrate the effectiveness of water cannons for use in controlling fires in large, remote military testing and training ranges.

Management

- Accomplish planned vegetation mapping.
- Better educate the public to overcome social perception issues related to the use of prescribed fire.

Restoration

Research

- Improve understanding of both the desired endpoint and the starting point for the dry forest/grassland. This includes understanding the composition, structure, processes, and functions of flora and fauna (i.e., role in the ecosystem), and determining the historic properties (function, composition, etc.) of dry forest systems.
- Identify ways to improve restoration efforts (e.g., replacing guinea grass, improving plant propagation techniques, and determining the reproductive success of existing and outplanted native plant species following initial restoration efforts).
- Review near-pristine conditions to determine the best species to select for a viable restoration project.
- Develop high-resolution vegetation mapping as a tool for restoring and monitoring dry forests/grasslands. Consider the use of LIDAR and hyperspectral techniques to identify NIS plants.
- Determine optimum restoration approaches, starting with a somewhat intact forest. For example, develop a technique to restore forest starting at the edge of the intact forest and expand outward.
- Develop a methodology to prioritize critical lands (for TER-S species), including potential buffer lands outside DoD ownership.
- Investigate the use of toxicants for ungulate control.

Management

- Describe starting point conditions for the dry forest/grassland.
- Develop a restoration handbook for land managers, including “how to” procedures, prioritization of starting points, and achievable endpoints.
- Improve firefighting capacities and techniques at military installations.

5.2 WET FOREST SYSTEMS

Dr. Flint Hughes, U.S. Forest Service—Institute of Pacific Islands Forestry, chaired the Wet Forest breakout group, which discussed the extent of this ecological system and associated TER-S on regional DoD lands; identified current and future system stresses; and determined needs relevant to monitoring, adaptive management, and restoration. The group defined wet forests principally as all windward forests; however, especially on low islands, wet forests also can be found on the leeward side. Dieter's more formal definition encompasses temperature and humidity.[14] Among DoD lands in the region, wet forests are largely found on Army-managed lands. These forests provide habitat for numerous TER-S as well as many other more common native species (Table 3). The group also expanded their charge to consider caves and karst landscapes in the region.

Table 4. Extent of Wet Forests on DoD Lands and Associated TER-S[15]

Location	Service	TER-S
KMR, Hilo	ARNG	Hawk, bat, cave-dwelling invertebrates, special ecosystems
Ka'ala, Oahu	AF	Potential snails, elepaio
Makua, Oahu	Army	10+ plants (not all in wet forest), snails, elepaio
Schofield, Oahu	Army	10+ plants, iiwi (state listed), elepaio, snails (10 species among Kahuku/Schofield/Kawailoa), damselfly
Kahuku, Oahu	Army	Bat, snails, 10+ plants, forest birds, damselfly
Koke'e, Kaua'i	Navy/AF	Bats, green sphinx moth
Kawailoa, Oahu (in Ko'olau)	Army	10+ plants, bat, elepaio, damselfly, goby

Stresses impacting wet forests were identified then sorted according to highest current priority, other existing stresses, and future stresses. The level of understanding for each of these stresses varies significantly (1 = low, 5 = high) and can be used to target future research and management attention (Table 4). All stresses were determined to be applicable to the wet forests and associated TER-S on DoD lands, as noted in Table 3.

Table 5. Understanding Stresses that Impact Wet Forests

Stresses	Level of Understanding	Notes
Highest Priority Current Stresses		
Invasive Species (*Miconia*, macaranga, guava, *Albizia*, melastoma, non-native ferns)	0-5	Less is known about non-fixing species (Nitrogen)
Loss of Native Species and Ecosystem Functions	1	For example, competition, pollinators, predators, soil modifiers, non-fixers
Ungulates/Other Herbivores	5 (ungulates); 1-3 (other herbivores)	Other herbivores refers largely to insects
Rats	5	Some outstanding issues regarding seed predation
Soil Loss, Erosion, Landslides	3	

[14] Dieter Mueller-Dombois. See http://ib.berkeley.edu/labs/dawson/publications/Santiago_etal_2000b.pdf.
[15] Some of these lands are largely improved with limited wet forest habitat or associated TER-S.

Other Current Stresses		
Development	2	Issues related to system fragmentation, including surrounding lands and development, which can be a direct or indirect on- or off-site stress
Soil Modifying Organisms	1	Earthworms, mycorhyzae, non-native invertebrates, amphipods, fungi
Fire	3-4	Periodic hazard, but when conditions are right, potentially catastrophic—especially given transitions between dry and wet forests
Military Facilities	5	For example, built infrastructure
Military Pathways for NIS	0-1	Vector issue
Military Operations	1	Disturbance, noise, electromagnetic radiation (future Stryker operations are an area of concern)
Future Stresses		
Climate Change	1	Range expansion of NIS, increase in category storms, dry and wet sides switch, species have to climb mountain, etc.
Disease	1-2	For example, Ohia rust (damage is known but actual impacts are not)

Monitoring is a key element of managing and anticipating these stresses so that ecological integrity is maintained and compatible with the DoD training and testing mission. Both inventory and monitoring data support studies on ecosystem function by establishing baselines from which to assess trends in response to stressors. Demography and health of dominant species also should be monitored regularly as a means of indirectly assessing TER-S trends. Overall, broader DoD support is needed for long-term monitoring efforts targeting ecosystems rather than imperiled species.

Adaptive management involves modifying management actions in response to monitoring data. In the wet forest, fencing followed by ungulate removal is a common management approach. This action frequently results in the influx of NIS plants, which are likely to grow and must be monitored. If their levels rise, they are removed. In this way, stressors are tackled through an adaptive management approach. The Makua Implementation Plan is based on adaptive management in support of stabilizing the threatened and endangered plants that could be destroyed by a catastrophic fire over the long-term. Once a year, the USFWS and U.S. Army meet to review results and modify future plans, as necessary. It is also possible to look at adaptive management as an experimental approach to better understand ecosystem processes and the impact of different stressors. This has been called a “management by research” approach.

In Hawaii’s wet forests, key species such as the tree fern are relatively intact so degraded systems can recover fairly well with management. For example, if you lose the Ohia, the forest can recover, but if you lose the tree fern, you essentially lose the forest. One reason the wet forest has survived is that dry forest plants, which are more widely used and survive being transported better, have been introduced more frequently than wet forest ones. Prevention of invasive wet forest plant introductions is a key area for military support.

Means to measure and assess ecosystem integrity, however, are needed in support of restoration. For example, monitoring ecosystem function as defined by nutrients, runoff, and leaching is an approach based not only on removing something but also on achieving a desired outcome. In

general, information on how to restore a highly degraded wet forest is lacking. Restoration approaches may differ based on the stressor (e.g., Ohia dieback, fire, ungulate damage). Beyond fencing and removal of ungulates, it may be necessary to remove invasive plants in a certain order, control erosion, and plant species other than Ohia. Awareness of site characteristics is also critical when planning successful restoration efforts (e.g., steep vs. shallow slopes, shaded vs. sunny slopes).

The following research, demonstration, and management needs were identified relevant to managing the wet forest ecosystem in the Pacific Islands region:

Research

- Monitor a suite of ecosystem functions (e.g., nutrients, hydrology) with varying levels of disturbance as a baseline for assessing impacts of stresses. For example, nitrogen runoff may serve as a measure of health in an *Albizia*-prone system.
- Determine thresholds of response for management action.
- Investigate ways to minimize disturbance in military context to prevent spread of invasives (e.g., pigs follow human trails, weeds along maintained fence lines).
- Develop tools, techniques, and protocols to prevent spread of NIS.
- Determine conditions that favor natives over NIS (e.g., low light), and develop a better understanding of how stressors alter those conditions.
- Determine whether Ohia is a keystone species, and assess stresses other than rust (e.g., for Hilo, hapu'u and Ohia combination is critical).
- Develop a framework for wet forest restoration that takes into account the stressor, series of management actions based on stressor, and site characteristics.

Demonstrations

- Demonstrate application of remote sensing technologies, radio telemetry, and motion detectors for assessing integrity of the wet forest system.

Management

- Monitor trends in dominant species (e.g., Ohia) and representative species (e.g., 'Amakihi) as a means to indirectly monitor trends in TER-S.
- Compile a comprehensive list of potential invasive threats to the wet forest beyond *Miconia*, other melastomes, and the Australian tree fern.
- Minimize collateral damage to TER-S from management of NIS.
- Conduct inventories of arthropods.
- When outplanting, ensure genetic diversity to guard against disease.

5.3 COASTAL/WETLANDS/RIPARIAN AREA SYSTEMS

The Coastal/Wetlands/Riparian Areas breakout group, chaired by **Mr. Barry Smith**, University of Guam, was tasked with identifying needs relevant to multiple listed and at-risk species within an ecological system context. The group identified several system processes and stresses of immediate and future concern that impact aquatic ecosystems in the Pacific Islands region. They categorized these processes and stresses into the following major categories:

- Global Climate Change
  - Sea level change
  - Seasonality patterns
  - Storm severity and frequency
  - Altered fire regimes
- Conversion of Native Ecosystems
  - Altered hydrology
  - Nutrient and carbon cycling and transport
  - Point and non-point source pollution
  - Altered fire regimes
  - Military training activities
  - Recreation and poaching
- Non-Native Invasive Species
  - Ballast water
  - Biofouling of ship hulls
  - Feral animals
  - Altered hydrology
  - Point and non-point source pollution
  - Altered fire regimes

Based on the impacts of these processes and stresses to Pacific Island ecosystems in general, and endangered species habitats in particular, the group identified a suite of pressing needs relevant to TER-S research, demonstration, and management. For example, to inventory, monitor, and assess the ecological integrity of coastal, wetland, and riparian areas and associated TER-S habitats, the group suggested investigating a variety of tools, approaches, and indicators. Additionally, while research questions and management efforts have the potential to yield high-quality results for TER-S conservation and preservation, conflicts can and have arisen when managing endangered species habitat, often because each wetland is unique. Currently, there are joint-force plans in effect or being developed for wetland areas in Hawaii. These must be referenced when conducting any inland or near-shore aquatic research, demonstration, or management efforts in the region.

Once conflicts have been resolved and the proper tools for surveying and monitoring TER-S habitats have been identified, restoration efforts can begin. The group discussed the state of current knowledge about restoring the ecological system when it no longer exists in an area or, when extant, its condition has been degraded. The group determined that since many restoration efforts are in the planning stages or are currently ongoing, a wealth of information does exist

and. Thus, prior to any restoration effort, research on past efforts should be undertaken to analyze both successes and failures.

Research

- Determine the native species composition that can best resist impacts from military training, storm events, and increased pollution.
- Define the optimal lapse in time between military training events to maintain TER-S habitat resilience.
- Identify the nutrient and carbon cycling and transport dynamics at the landscape, watershed, and near-shore coastal levels.
- Determine functional wetland size for storm mitigation.
- Examine the effects of large storms on near-shore areas and streams (i.e., flooding event data gaps).
- Identify and evaluate possible, if temporary, NIS habitat benefits.
- Clarify what information is needed to best manage disturbed versus natural systems.
- Develop BMPs for coral reef and wetlands mitigation methods.
    - Evaluate which species are best suited for coral reef restoration
    - Identify the most cost-effective techniques to transplant corals into degraded areas
    - Determine optimal substrates to facilitate coral restoration and transplantation
    - For wetlands, examine system hydrology to determine how it has been altered, if it can be restored to previous conditions and, if not, how practitioners can restore the area given current hydrological conditions
    - Develop a list of plants and groups of organisms best suited for wetland restoration[16]
    - Evaluate how are soils have changed due to the altered hydrology and land conversion
- Evaluate impacts of altered hydrology on water flow.
- Identify the various low-impact development (LID) techniques that can best serve the military during realignment, and evaluate their potential system impacts.
- Develop standardized monitoring protocols for aquatic habitats.
- Identify cost-effective ways of assessing soil condition prior to restoration efforts.
- Identify, locate, and map wet cave systems in Hawaii and Guam. Once identified, inventories for at-risk species need to be conducted.

[16] A Hawaii update is currently in press.

Demonstration

- Evaluate the effectiveness of quarantine and prevention methods to curb new introductions of NIS.
- Demonstrate how military training can be combined with the removal of marine debris and the monitoring of TER-S habitats.
- Investigate the possibility of using molecular techniques (e.g., microsatellite DNA) for tracking the movement of endangered organisms in and out of DoD property.
- Demonstrate the use of robots for ecosystem maintenance.
- Demonstrate environmental sensor networks (e.g., NEON/EPSCOR) to remotely monitor abiotic conditions.
- Demonstrate the use of remote sensing to enhance conservation law enforcement.
- Demonstrate the use of long-term remote monitoring buoys in near-shore coastal habitats.
- Investigate the use of radio frequency identification (RFID) chips and barcodes for aquatic TER-S.
- Validate the use of light detection and ranging (LIDAR) for coral health, mapping, and hydrology in wetlands.

Management

- Identify and evaluate the positive impacts of military training on TER-S.
- Identify and implement techniques to make conservation law enforcement more stringent.
- Investigate methods for minimizing use of optimal habitat and seasonality to facilitate military training.
- Use the best "green"/ LID approaches for new facility developments.
- Use available lowlight options for new coastal development and security.
- Increase and improve use of conservation buffer zones to preserve high value habitats.
- Train and use taxonomists (i.e., parataxonomists) for component identification in support of a current database of TER-S in the Pacific Islands region.
- Reform the DoD contracting process to include long-term management/ monitoring approaches and funding mechanisms.
- Monitor and manage wetlands for TER-S. Specific attention should be paid to:
  - The role of wetlands
  - Suitable water levels, quality, and hydrology for single and groups of TER-S

  - Best groups of species for restoration efforts
  - Use of native species for water quality monitoring
  - Potential role for wetland mitigation banks in the Pacific Islands region

- When undertaking restoration efforts, use native or introduced species that benefit TER-S.
- Ensure funding for long-term continuous monitoring of aquatic habitats.

6.0 IMPACTS OF NON-NATIVE INVASIVE SPECIES ON TER-S BREAKOUT SESSION

Due to their evolutionary history and high levels of endemism, native plants and animals in the Pacific Islands region are particularly susceptible to threats posed by the introduction and spread of non-native invasive species (NIS). An invasive species is defined as a species that is not native to the ecosystem under consideration, and whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112). In the Impacts of NIS on TER-S breakout session, groups divided into Aquatic NIS (freshwater and marine), Plant NIS, and Animal NIS. The outcome objective was to identify needs relevant to combating NIS threats to TER-S.

To set the stage for the breakout group discussions, **Dr. Al Cofrancesco**, U.S. Army Corps of Engineers—Engineer Research and Development Center, gave a presentation on the impacts of NIS to the military in terms of troop and equipment movement, training, and operations. Impacts included delays, significant expenditure of resources (labor and funds), and degradation of training lands.

The National Invasive Species Council Pathways Work Team has developed a guide for ranking pathways, which identifies transportation-related pathways, living industry pathways, and miscellaneous pathways (June 2005). Military pathways primarily fall under transportation-related pathways—baggage, equipment, and troops—although ecosystem disturbance, which may result from military training, is identified under the miscellaneous category.

Military training activities (e.g., tracked vehicles, foot traffic) have the potential to facilitate spread of NIS through ecosystem disturbance. Examples of NIS impacting the military include salt cedar, *Arundo donax*, and yellow starthistle, infestations of which have constrained training activities and degraded habitats for TER-S and other native species. Control often requires a combination of prescribed burning, chemical treatment, and biological approaches. Further, where revegetation is required following control, associated costs increase significantly.

In an effort to reduce the unintentional spread of NIS, DoD has implemented rigorous inspection and cleaning requirements. The goal is to prevent the spread of agricultural pests as a result of the military's movement of baggage, equipment, and troops to and from the United States. Cleaning times are extensive (e.g., 14-24 hours per tank), and associated labor costs are significant. Over a 9-month period, 228,393 personnel, 65,541 vehicles, 7,385 conexes, 9,857 containers, and 275,915 packages were shipped out of Kuwait. The total cost for washing and inspection during this period was approximately $16 million.

Military operations at sea also have the potential to spread NIS through ballast water, hull fouling, and sea chest infestations; however, this pathway has been shown to be less of a concern, since military vessels account for a small fraction of total sea movements in the region.

Given the significant impact of NIS on the military and TER-S, broad areas of need include prevention, early detection and rapid response, control and monitoring, education and outreach, restoration, and research. Plans such as the State of Hawaii Aquatic Invasive Species

Management Plan enhance the coordination of current management efforts, identify remaining problem areas and gaps, and recommend additional actions (September 2003). Further, the U.S. Army Corps of Engineers has developed CD-based information systems on invasive plants and their dispersal, which could be updated for species in the Pacific Islands region.

6.1 AQUATIC NIS

The Aquatic NIS breakout group, chaired by **Dr. Dan Polhemus** and **Mr. Dave Gulko**, Hawaii DLNR – Division of Aquatic Resources, was tasked with identifying needs relevant to combating threats posed by NIS to aquatic TER-S throughout the Pacific Islands region. The group identified several NIS that are of high priority because of their immediate and potential future impacts to aquatic ecosystems. Participants also noted that NIS need to be categorized sub-regionally. For example, mangroves are considered to be highly invasive in the Hawaiian Islands, but they are native and an integral part of the ecosystem in Guam. The group therefore categorized NIS not only by freshwater and saltwater ecosystems, but also by sub-region (Tables 5 and 6). They noted that most, if not all, NIS are a high priority because of their potential to convert TER-S habitat at a rapid rate. For a comprehensive NIS list, readers should refer to the compiled list of NIS from the Hawaii Invasive Species Council (http://www.hawaii.gov/dlnr/dofaw/HISC/).

Table 6. Saltwater NIS of the Pacific Islands Region.

[*Those denoted with an (H) are of particular note in Hawaii; those noted with a (G) are of particular note in Guam*]

Algae	Plants	Invertebrates	Fish
Acanthophora (H)	*Batis maritima*	*Carajoa resii*	*Cephalopholis argus* (Roi)
Avranvillia	Intertidal grasses	*Cassiopea* spp	*Lutjanus kasmira* (Ta'ape)
Cladophora (G)	*Rhizophora mangle*	Chironex fleckeri	
Caulerpa taxafolia		*Gelloides* (H)	
Gracillaria spp.		*Mycalefarmeda* (H)	
Hypnea spp.		Barnacles	
Kappaphycus complex			

Table 7. Freshwater NIS of the Pacific Islands Region

Plants	Invertebrates	Fish	Other Vertebrates
Azola spp	*Aedes culex*	*Channa striata*	*Chrysemys scripta elegans*
Echhoria crassipes	*Cheumatopsyche* spp	*Clarias fuscus*	*Pelodiscus sinensis*
Elodia spp.	*Corbicula flumminea*	*Gambusia affinis*	
Hydrilla verticillata	Leeches	*Hypostomus* cf. *watwata*	
Melaluca quinquenervia	*Pila conica*	*Micropterus dolomieui*	
Pistia stratiotes	*Procambarus clarkii*	*Oreochromis* spp (Tilapia)	
Salvinia molesta			
Schinus terebinthifolius			
Typha latifolia			

In addition to the established species identified in Tables 5 and 6, the group identified some potentially harmful NIS that have not yet spread or become significant (i.e., incipient species). These organisms have the potential to become problematic should their invasion continue. Saltwater species include *Lyngbya* (blue-green algae), *Dictyospheria* spp. (G), *Spartina anglica*, Hydrocorals, *Eriocheir sinensis*, and some Tunicates. Freshwater organisms include two turtle

species from Guam, *Potamopyrgus antipodarum*, *Arundo donax*, and several freshwater algae species.

For these priority aquatic NIS, the group then identified geographic areas that are lacking information on the current status of NIS. In general, remote areas lack information, especially:

- Marine Areas/Hawaii
  - Barking Sands beach and areas north of Barking Sands
  - Marine Corps Base Hawaii
    - Kaneohe Bay
    - Waimanalo Bay
  - Hickam Air Force Base
    - Fort Kamehameha
- Freshwater Areas/Hawaii
  - Kawailoa Training Area
  - Waikane Training Area
- Marine Areas/Pacific Islands Region
  - Wake Atoll
  - Northern areas of Tinian
  - Kaula Island
  - Farallon de Medinilla (FDM) in the Northern Marianas

Because of the high rate of endemism in the Pacific Islands region, NIS have impacted, are impacting, and have the potential to severely impact various TER-S habitats on both small and large scales. The invasion of NIS into an ecosystem can make that system more susceptible to further invasions and/or degrade habitats to irreparable conditions. Current and future threats and associated research questions for aquatic ecosystems in terms of the incursion of NIS include:

- Ecological Phase Shifts
  - Maintenance of ecological integrity in a system with NIS
  - Transformations of ecosystem processes that will occur with the invasion of non-native species
  - Trophic relationships for TER-S within an ecosystem and impacts of NIS
- Synergistic Effects of Abiotic and Biotic Factors
  - Impact of increased nutrient input into aquatic systems in terms of allowing an NIS to out-compete TER-S for space and food resources
- Degraded Habitat
  - Spatial displacement of native species
  - Ecological thresholds of habitat degradation that native species can withstand
  - Threshold/minimum critical habitat size required by native TER-S
  - Symbiotic relationships that exist within native aquatic ecosystems and impacts of NIS
- Installation of an Inter-Island Super Ferry
  - Protocol for cleaning and movement between ports within Hawaii

The most significant issue facing natural resource managers in the Pacific Islands region is controlling the influx and spread of NIS. Knowing the actions needed to prevent the introduction and spread of NIS is half the battle. While several tools exist to help managers with these tasks, further research is needed to develop more cost-effective tools. Research also is needed to convert current technology used in terrestrial habitats for use in aquatic habitats. These issues are not DoD-specific, and should be addressed in partnership with state and federal agencies, private industry, and citizens. The group came to the consensus that standardized inspection protocols, and the addition of clauses for self-inspection need to be included in contracts for outsourcing and intra-DoD hiring. Specific actions recommended to prevent the introduction and further spread of NIS include:

Research

- Clarify security issues involved with inspection of ships and associated military gear.
- Quantify the vector overlap between military and civilian transport of NIS.
- Identify and evaluate the threat for potential transfer and movement mechanisms for NIS.
- Identify the key components of NIS assemblages and outbreaks.
- Quantify any ecosystem services provided by NIS and their ability to act as viable surrogates in degraded habitats until native species can re-colonize.
- Define the desired end states for restoration projects (e.g., pre-European, pre-Hawaiian).
- Quantify the impacts of removing NIS in highly altered systems.

Demonstration

- Validate and evaluate effectiveness of various existing approaches to prevent inter-island movements of NIS.
- Evaluate and make available cost-effective protocols and tools for:
  - on-site cleaning of individual gear
  - preventing fouling of ships in dry dock and during inspection
  - preventing NIS introductions
  - early detection of NIS
- Inventory and assess existing tools and protocols with regard to site-specific effectiveness and potential new uses.

Management

- Standardize vehicle and equipment documentation and inspection protocols.
- Ensure direct and informed oversight of outsourcing contractors.

- Prevention
  - Use antifouling paints and coatings on ships
  - Stop release of aquarium fish into the wild
  - Stop restocking fishing areas with non-native fish
  - Minimize standing water
- Early detection
  - Inspect ships for hull fouling
  - Inspect sea chests[17]
  - Inspect dredges
  - Inspect ship ballast water
  - Use Remotely Operated Vehicles (ROVs) to inspect the above-mentioned areas
  - Inspect docks, piers, and platforms
  - Inspect personal recreational and military equipment that may contain NIS fragment
- Rapid Response[18]
  - Treat all introductions as possible invasions

In addition to NIS that impact TER-S habitats, there is a growing concern for the introduction of pathogens that have the potential to directly impact both species and human health (Table 8). Many of the current pathogens are or can be waterborne, and people should take great care when working and recreating in aquatic environments. A major question facing scientists is determining organism infections, the spread and mutation of these pathogens (i.e., if human diseases can be transferred to wildlife and vice versa), and threshold levels that native populations can withstand before becoming a genetically inviable.

Table 8. Current and Future Threats Posed by NIS Pathogens

Current Threats
Resistance to cholera
Fibropapiloma
Leptospirosis
Giardia
Freshwater fish pathogens
Nematodes
Acanthocephaleus
Botchelism
Future Threats
Coral and coralline algae diseases
Avian flu
West Nile virus
Schistosomes

[17] Sea chests are recessed areas of ship hulls that house intake water pipes for engine cooling, ballast, and fire-fighting.
[18] Early detection and rapid response (ED/RR) are generally considered together.

6.2 PLANT NIS

Dr. Earl Campbell, U.S. Fish and Wildlife Service, chaired the Plant NIS breakout group. This group discussed invasive plant issues and identified associated needs in three categories: established species, incipient species, and prevention activities. Established or legacy species are species that are managed in perpetuity in an area. Incipient species are present but are not yet a significant problem—early detection of these species is critical. Prevention addresses those species that are not present, and whose introduction is avoided through regulations, inspections, washing, etc. The Hawaii Invasive Species Council (HISC) and island-based committees primarily work on established and incipient species, though these groups also play a role in prevention through weed risk assessment. Species lists are available by island and updated annually.

Established species issues are extensive in the region, with non-native grasses representing the most significant threat to DoD lands. Non-native grasses are now found in all systems throughout the region, with the exception of alpine. These grasses not only occupy the land, displacing native species, they also change fire cycles and alter entire microclimates within a system. All are perennials; some are spreading and some are bunching species. Examples of non-native grasses and other established species (including herbs, trees/shrubs, vines, and ferns/mosses) are provided in Table 8. In addition to monitoring and mitigation (including control and restoration), there is a need to better understand the impacts of plant NIS on ecosystem integrity.

Unlike established species, incipient species are less well-inventoried and their extent is not known. This knowledge gap makes it difficult to identify threats, assess population trends, and measure the success of intervention efforts. For example, despite its high-profile status, there is no complete inventory for *Miconia* in the region. Thus, interagency information sharing is critical to leverage survey data, and to facilitate pathway prediction. Following detection, rapid response to eliminate incipient species is essential. Incipient species vary significantly by island and site (e.g., fountain grass is incipient in Waimanalo and established in Diamond Head).

In terms of inspection, although $2 million recently has been set aside by Hawaii to hire 25-30 new agricultural inspectors for international and interstate shipments, there is a need to examine NIS more systemically to prevent future introductions. Similar to the invasive species committee species lists, weed risk assessment lists are being developed (this effort is complete for woody plants). Yet, better integration of these assessments with information on potential pathways, sources, and species is still needed. For example, introduction of the gall wasp (which impacts wiliwili) may have been prevented through better access to global information. Similarly, the sale and distribution of NIS ornamental plants, which comprises a significant source of NIS for DoD, could likely be curtailed through better information exchange, coupled with information on viable/marketable alternatives.

Table 9. Established NIS Plant Issues in the Pacific Islands Region

Non-Native Grasses	Herbs	Trees/shrubs	Vines	Ferns/Mosses
• Fountain grass • Guinea grass • California grass • Molasses grass • "Bunch grasses" • Buffle grass • Kikuyu grass • Palm grass • Sword grass • Bamboo	• *Clidemia* • Senecio— fire weed • Russian thistle • Gingers—kahili • Akuiku—*Batis maritama*	• *Miconia* • Guava • Kiawe • *Pluchia* • Coffee—Makaha • *Albizia* • *Rubus* • All melastomes • *Schinus*—Christmas berry or Brazilian pepper • Klu • Gorse • Fiddlewood • Silk oak • Ironwood • *Myrica* • *Leucanea*	• Ivy gourd • Passion flower • Maile pilau • Chain of love • *Thunbergia* • Bitter melon	• Peat moss • Sphagnum • Sword fern • Australian fern • Mule's foot fern

The following needs were identified by category for established and incipient species, and for preventing future NIS plant impacts to TER-S.

Established Species Needs

Research

- Develop tools that provide information on the distribution and impacts of NIS, particularly non-native grasses and non-native pollinators, on system structure.
- Determine acceptable levels of NIS in native ecosystems (i.e., system function remains intact).
- Develop techniques for reducing fuel loads in native habitats.
- Identify and evaluate erosion risk in NIS-dominated areas.
- Build capacity for biocontrol through additional research on control agents for NIS found in their native habitat.
- Develop new chemical approaches for control (e.g., designer herbicides) that minimize collateral damage to native species. For example, approaches may include C4 vs. C3 inhibitors or enzymes that disrupt silica uptake. These approaches should impact a range of species and leverage existing EPA-approved products.
- Pursue designer biocontrol research (i.e., genetically modified organisms).

- To guide management efforts, develop methods to assess the seed bank composition and viability. For example, how long does it take to exhaust the seed bank of a non-native grass with burning and herbicide cycles?
- Evaluate non-native animal-mediated interactions with the spread of non-native grass and woody NIS (e.g., pigs spreading guava, birds spreading *Miconia*, ungulates spreading NIS grasses).
- Develop treatment protocols for NIS control.
- Research the conditions and competitive interactions that favor natives over NIS so that systems can be manipulated in support of restoration (e.g., reduce nitrogen in *Albizia* sites to get natives to grow).
- Develop protocols for removing NIS plants and restoring natives, such that TER-S interacting with NIS are not significantly impacted (e.g., elepaio using/preferring guava and sphinx moth/tobacco).
- Enhance spatial data through NIS inventories.

Management

- Leverage ongoing work on biocontrol for guava and *Miconia*.
- Support fire hazard assessments in areas impacted by non-native grasses, implement weekly/monthly analysis of moisture content, seasonal analysis of fuel loading, and annual analysis of distribution (apply remote sensing tools to map fuels).
- Develop BMPs for restoration efforts, including removal of NIS, site conditioning, replanting, and ensuring successful reproduction of natives.
- Identify and ensure availability of viable replacement species (native and non-native) for restoration efforts post-treatment of NIS.

Incipient Species Needs

Research

- Conduct surveys for incipient NIS.
- Model patterns of invasiveness.
- Develop ability to rapidly predict sites of concern using models.
- Conduct surveys of high-risk sites using regionally standardized protocols; share data using collaboration tools and software.

Demonstration

- Utilize remote survey techniques such as high-resolution aerial imagery and unmanned vehicles for NIS vegetation.

Management

- Facilitate DoD participation in broader, interagency early detection and rapid response (ED/RR) networks. This would encompass a network of people, reporting mechanisms, parataxonomist assessments, technology to bridge gap between detection and response, communication of reports to network of managers, and evaluation based on past experience with goal of refining system (i.e., feedback loop).
- Ensure Memoranda of Agreements are in place for rapid response.
- Preposition people, materials, and equipment to rapidly respond as soon as incipient species are detected; leverage invasive species committees.
- Compile a database of incipient species' treatment efforts in other locations (including lessons learned) that may be adapted to Pacific Islands region in support of a list of techniques that can be readily employed.

Prevention

Management

- For early detection purposes, provide support to keep weed risk assessment models current and relevant to the region by incorporating new information for Hawaii, and expanding them to include Guam and Marianas ornamental species.
- Integrate early detection networks to access global information on potential pathways, sources, and species (e.g., gall wasp).
- Improve training and increase level of awareness for military inspection units to ensure that quarantine inspection standards are at the level they were when DoD had its own customs program (pre-1991).
- Educate public and nursery industry about NIS ornamental plants, create incentives for not selling them, and provide information on viable/marketable alternatives for ornamental plants.
- Support native plant horticulture.
- Following the U.S. Marine Corps example, DoD should encourage all installations to prepare a comprehensive lists of State and federal high-risk and native plants, and bans the planting of NIS on base.

6.3 ANIMAL NIS

Dr. Frank Howarth, Bishop Museum, chaired the session on Animal NIS. He began by challenging the group to identify the most important NIS—both current and potential. The group responded by identifying several important NIS animals in six categories. Of these, the group considered brown tree snakes (BTS), pigs, and rats the three most important NIS animals in

Hawaii. In Guam, BTS, pigs, and deer were considered the top three. During discussions, lists of NIS animals were categorized as follows:

- **Vertebrates:** BTS, pigs, rats, deer, sheep, goats, caraboo (water buffalo), snakes, frogs, cats, dogs, mongoose, lizards, and birds.
- **Social Insects:** Ants (most significant), yellow jackets, honey bees, scales, and aphids.
- **Diseases and Vectors:** Avian influenza (birds), leptospirosis, west Nile virus, pox (e.g., plum pox), malaria (mosquitoes), and other insect diseases.
- **Parasitoid Flies and Wasps:** Those affecting threatened and endangered arthropods.
- **Others:** Gall wasps and black twig borer.
- **Emerging Species:** Biting midges, sand flies, parrots, chameleons, and other non-native birds

From that list, the group then identified knowledge gaps and actions needed to prevent introductions of NIS animals. The group discussed inventories, monitoring, and perceived DoD roles in these efforts. In terms of survey and detection methods, participants agreed that standard survey and detection protocols are needed. They advocated the use of hyperspectral imaging, though acknowledged its limitations.

With respect to control, several issues were raised. Of particular note was a discussion concerning the long administrative and testing period needed to approve the use of new toxicants and toxicant delivery methods. It was suggested that DoD may have a role in the registration process, possibly through the Armed Forces Pest Management Board. It was further suggested that DoD could supply one person-year to help in the registration of toxicants for slugs and snails. For early detection/rapid response efforts, the Hawaii National Guard may be able to assist in gaining access to private lands similar to the way it assisted in recent dam control management. The group also discussed issues related to the use of biocontrols, and the need to consider their impacts at an ecosystem level.

Finally, the group discussed how best to prevent introductions, especially of known NIS such as the BTS. Prevention management, they determined, benefits from the examination of past failures. One management action that needs advocacy is rapid response to introductions. Administrative burdens hamper rapid response; a paradigm shift must take place if managers are to put an effective rapid response procedure into action. Search methods at introduction sources are also important elements of prevention. It also was noted that opportunities exist for researching or validating new, effective methods for searching (e.g., using dogs or traps).

The group identified a variety of specific actions and initiatives that DoD and others could undertake.[19]

[19] These are grouped to aid readability.

Detection and Control

Research

- Develop better protocols for surveys: identifying the best scale for management, improving detection methods (scale and timing), and improving mapping and analysis techniques for management.
- Improve modeling/understanding of animal movements and behavior (e.g., movement of pigs in and out of military installations).
- Develop innovative controls for NIS animals to include baits and trapping, contraception delivery methods, toxicants, molecular engineering, research and data development to register new toxicants/pesticides (e.g., caffeine toxicant for cannibal snails), and biocontrol protocols and agents.
- Develop better lures and attractants for non-native invasive animals.

Demonstration

- Validate existing NIS animal controls—those that are mature from an R&D standpoint, but have not yet been tested in the field (e.g., testing New Zealand style pest excluder fencing on highly porous pahoehoe lava substrates commonly found in Hawaii).
- Adapt military technology for detection of NIS animals (e.g., night vision technologies).
- Adapt military technology for detection of low density or rare NIS animals.
- Review and apply, as appropriate, what is or has been done in other regions and countries for control of NIS animals.

Management

- Develop streamlined/emergency registration procedures for control agents.
- Transfer technology The Nature Conservancy developed for integrated feral ungulate control methods.

Ecosystem Integrity

Research

- Determine the long-term trends within various Island ecosystems.
- Determine ecological thresholds for management of NIS (i.e., the population levels of NIS that will still allow for sustainable TES recovery).

- Learn more about the impacts of eliminating NIS in altered systems (e.g., elimination of native pollinators and the effect such elimination has on native plant reproductive success) as well as timing and sequence for removal—for example, the related predator/prey effects).
- Develop a risk assessment model for NIS animals similar to the one being developed for plants.
- Understand the effect of global warming on the distribution and impacts of NIS animals (e.g., mosquitoes).
- Improve understanding of ecosystem responses to removal/introduction of species (i.e., understanding interactions among NIS animals and the ecosystem).

Prevention

Research

- Examine past failures to help in the development of better rapid response protocols.

Demonstration

- Conduct systems analysis of military transportation (i.e., model is available but not tested).
- Perform a risk analysis of BTS and other NIS animal pathways, including an appropriate inspection process.

Management

- Improve introduction prevention methods at the point of origin (e.g., through stronger partnerships).
- Improve quarantine at the site of introduction. DoD cleans equipment well, but are inspections adequate? What is done when something is found?
- Develop a rapid response capability, including protocols and logistics, for newly introduced NIS animals.
- Develop a network of information on incipient, NIS animal threats.
- Cross educate state and federal customs agents. This, for example, would have benefits for the special ant rules.
- Educate DoD transportation agents on NIS animal issues, especially ants.

7.0 TECHNOLOGY TRANSFER BREAKOUT SESSION

While it is generally accepted that leveraging information and working in partnership across organizations conserves resources and is critical to any successful conservation and restoration strategy over large geographic areas, it became clear during review of the pre-workshop questionnaires that this coordination was not always taking place among relevant stakeholders in the Pacific Islands region. In fact, while many groups and individuals are working on TER-S and NIS issues, a large percentage of respondents indicated that groups often did not communicate effectively with one another. Consequently, the workshop organizers created a follow-on session to help facilitate Information Sharing, Coordinated Management, and Partnerships among workshop participants. The session's outcome objective was for participants to identify collaborative opportunities at multiple spatial scales.

Dr. Michael Robotham, Tropical Technology Specialist for the Natural Resources Conservation Service, provided the overview presentation for this session. Dr. Robotham stressed the importance of leveraging information and working in partnership across organizations. To do this, he highlighted four areas for collaboration: information sharing, contractual relationships, multi-agency relationships, and multi-stakeholder management efforts. He then discussed the benefits and challenges within each of these areas for collaboration. Challenges, such as different formats for information collection and different entity goals and expectations, were contrasted with potential benefits including facilitation of more and better information exchange and achieving the diversity of expertise necessary for integrated, ecosystem/watershed-scale efforts.

By way of example, Dr. Robotham cited the Hawaii and Pacific Islands Cooperative Ecosystem Studies Unit (CESU) as an example of an existing mechanism for collaboration that could be expanded beyond being an efficient way to combine funds from different entities.[20] Similarly, sharing information across departments, agencies, and organizations can greatly facilitate and improve managing TER-S. Further, databases (such as the Hawaii Ecosystems at Risk site and DoD TES Document Repository) increasingly are providing access to the gray literature. However, when sharing information from specific biological data to general species information, awareness of metadata requirements, availability of historic and current information, logistics of management, information currency, and integration of multiple resources (e.g., TES plant permitting) must be addressed.

In conclusion, Dr. Robotham stated that more widespread access to TER-S information could enable additional gaps in knowledge, technology, and management to be identified for targeting future efforts (e.g., graduate program research), and that by communicating and cooperating on a regular basis, partners can work collaboratively to benefit TER-S conservation.

7.1 INFORMATION SHARING

Mr. Sky Harrison, U.S. Geological Survey—NBII, Pacific Basin Information Node (PBIN), chaired the Information Sharing breakout group. This group discussed and identified needs relevant to information sharing at multiple spatial scales, such as coordinating inventory and

[20] See www.**cesu**.org/ for more information on the Cooperative Ecosystem Studies Unit Program.

monitoring programs, using common standards and protocols, leveraging databases, and expanding public outreach/communication efforts. Questions (in italics below) were provided to guide participant discussions.

It is a requirement that agencies or landowners provide TER-S data to the USFWS on population status in the wild; propagation; reintroduction, out-planting, and survival; and management activities. Information relevant to plants must be provided by those receiving federal funds; whereas, animals are protected wherever they occur.

However, for information sharing to be successful in conserving financial resources and impacting conservation and restoration over large geographic areas, stakeholders must be able to share information easily, efficiently, and in a useful manner (e.g., common format and quality). Factors impacting successful information sharing efforts include:

- Institutional willingness (i.e., culture of information sharing)
- Initial investment of project/program time in developing and implementing standards/protocols for data collection, storage, and reporting
- Data quality (periodic review)
- Metadata (data about data)
- Appropriate technology
- Formal data sharing policy

Incomplete or poor data sharing and reporting from stakeholders makes it more difficult and tedious to determine impacts of an individual agency or landowner on a species. Consequently, managers must always err on the side of a species, perhaps implementing greater conservation and management efforts than may actually be necessary.

Despite the benefits of information sharing, monitoring data is generally not shared among stakeholders, and incentives may be needed to change this. For example, the Division of Aquatic & Wildlife Resources Guam conducts monitoring on Anderson AFB. In the past, data has not been accessible to the base or, because of publication requirements, its dissemination has been delayed. Further, given different cultures among researchers and managers, there is a question of what constitutes legitimate data. Academics want evermore refined data (one more plot, one more year); whereas, managers need to make real-time decisions using the best available information.

How can inventory and monitoring programs be coordinated to expand the spatial scale of these activities?

In support of a comprehensive web-based information exchange portal (including collaboration capabilities), the group recommended development of an online Projects and Research Catalog for activities in the Pacific Islands region. For each project, information on methods and protocols would be available. By leveraging existing resources such as PBIN, the portal could be enhanced with an associated document repository, bibliography, images, GIS capabilities, and web-based publishing (e-journal).

Specific needs to coordinate inventory and monitoring programs include:

- Assess what stakeholders are doing and where
- Coordinate on-the-ground efforts logistically
- Use common standards/protocols, including indicators
- Establish requirements in permits to share information
- Implement unique naming convention for TER-S populations
- Encode data to secure locations of TER-S

Are there accepted standards/protocols for data collection? If not, how can these be developed?

While there are some accepted standards/protocols for data collection (e.g., Hawai'i Rare Plant Restoration Group [HRPRG] and Association of Natural History Museums), standards/protocols are generally lacking, and should be developed in support of information sharing. The challenge is to create a core group of common elements—metadata is an important tool in this area. In the absence of standards/protocols, it was recommended that methodologies be thoroughly documented. The group recognized that development of standards/protocols for data collection may not be possible for all taxa. For example, plants may require several standards/protocols for use in different systems. Standards/protocols for data collection also will facilitate the future availability of data in a form usable by researchers and managers (i.e., methods, locations, timing).

Do centralized databases on current and past insular ecological research and management exist? If so, what additions to their content may be useful?

The following databases on ecological research and management were identified:

- Research
  - NPS (36,000 reports)
  - USFWS Permits
  - SERDP and ESTCP Online Library
- General Species Info
  - Integrated Taxonomic Information System (ITIS)
  - NatureServe
- Management
  - DoD TES Document Repository
  - Legacy Tracker
- Species Observations
  - PBIN
  - Heritage Database/NatureServe
  - Audubon Bird Database
  - Vouchered Collections

Useful additions to these databases identified by the group include:

- Gray literature/technical reports
- Integrated catalog of research projects (past and present)
- Legacy/historical information in electronic format
- Raw data, including methods, locations, timing (open source format)
- Museum-vouchered specimens/photographs from surveys, including information on data collection methodology for quality assurance
- NIS distribution data in GIS format
- Monitoring data on species distribution and status (population dynamics)
- Genetic information (GENBANK)
- Threats
- Identification guides/aids

How can DoD get the word out about its TER-S management successes and needs?

- Develop and maintain installation web sites
- Promote attendance at conferences, symposia, meetings
- Host field days
- Engage mass media (e.g., newspaper articles)
- Volunteer in larger community efforts

From an information sharing perspective, how can researchers more effectively communicate with resource managers and other end-users?

Researchers and managers in Hawaii, in general, cooperate very well. There are a few exceptions (e.g., when researchers and managers are under separate lines of administration). A codified agreement to share information is needed.

Specific to information sharing, the group discussed non-peer reviewed journals for online presentation of results (e.g., e-journals managed by a credible editor but not peer-reviewed). Incentives likely would still be needed for participation given the academic tenure and promotion system. However, if viewed as a step or series of steps before publication, such online journals may be a good forum to more quickly get data and technical reports into managers' hands. Quality control issues must be stressed.

Anecdotal/institutional knowledge (e.g., plant growing methods) is typically accessible by canvassing colleagues. The group suggested placing a message on the Hawaiian Ecosystems at Risk (HEAR) web site to identify individuals working on particular topics to aid in locating relevant information.[21]

7.2 COORDINATION OF MANAGEMENT ACTIVITIES

Mr. Lewis E. Gorman III, U.S. Fish and Wildlife Service, chaired the session on Coordinating Management Activities. The general objective was to identify collaborative opportunities for coordinating management activities at multiple spatial scales. Mr. Gorman led the group in

[21] See www.hear.org.

discussing TER-S areas associated with the DoD that warrant improvements in cooperative conservation. The group first discussed natural resources planning documents that are currently in use in the Pacific Islands region, and assessed whether or not the documents include conservation value statements. The group then considered other elements of current planning documents and the degree to which these are integrated or coordinated. Finally, areas for improvement in natural resources plan implementation were addressed.

Plans of high interest to the military are implementation plans resulting from Endangered Species Act (ESA) Section 7 consultation and installation Integrated Natural Resources Management Plans (INRMPs) required by the Sikes Act. Individual species Recovery Plans exist as a requirement of the ESA. Other federal agency natural resource plans include General Management Plans used by the NPS, and Habitat Management Plans (now also Comprehensive Conservation Plans) for USFWS national wildlife refuges. The state of Hawaii has recently developed a Comprehensive Wildlife Conservation Strategy, several Natural Area Reserve plans, and nine Watershed Management Plans. The Nature Conservancy has developed an Ecoregional Plan. Some plans include suites of species, such as the Shorebird Conservation Plan, Forest Bird Plan, and Seabird Conservation Plan. Other natural resources management plans include coral reef management plans, fire management plans, annual plans of the Invasive Species Committees, and the Pacific Joint Venture.

These plans range widely in content and organization, but generally include some statement regarding the value of conservation. The group agreed that most plans include a watershed perspective, TER-S management issues, and consideration of land ownership. The State is moving toward a watershed perspective. Military installation INRMPs vary considerably. Some offer a broad perspective, going beyond the legal compliance requirements, while others do not. Several participants considered current INRMPs to be interim in nature, and believe they will improve as they are revised.[22]

Irrespective of plan quality, development and implementation generally are too often not well integrated/coordinated. Examples of plans that have been implemented in a coordinated fashion are the Mountain Alliance Plan, annual plans of the Invasive Species Committees, the BTS implementation plan, and implementation plans that result from ESA Section 7 consultations.

Following are suggestions for improving coordination of natural resource planning:

- Measure and communicate results of plan implementation.
- Exchange information in a meaningful way.
  - Focus on information exchange within ecotypes
  - Adopt or develop a regional clearinghouse for environmental documents
- Encourage group interaction (e.g., Invasive Species Council).
- Develop a forum for cross-agency review of R&D needs, progress in meeting goals/objectives, implementation, and prioritization of projects. Possible

[22] See http://www.fws.gov/endangered/DOD/inrmp.pdf for more information on INRMPs.

mechanisms for better cross-agency coordination are the Hawaii Conservation Alliance and the Hawaii and Pacific Islands CESU.

The group concluded that there are collaborative opportunities for coordinating management activities at multiple spatial scales. They identified the following opportunities or needs for coordinating management activities with a TER-S and DoD nexus:

- Complete a landscape-scale demonstration of effective NIS control and fisheries management in Kaneohe Bay.
- Complete a functional landscape-scale watershed partnership in the Waianae Mountains.
- Develop a unified plan for ungulate management.
- Develop a unified plan for fire management.
- Use liaisons to focus species issues through the Hawaii Conservation Alliance or Hawaii and Pacific Islands CESU.
- Increase the effectiveness of the Hawaii Conservation Alliance.
- Use GIS as a management tool for interagency conservation coordination.

7.3 BUILDING PARTNERSHIPS AND OUTREACH OPPORTUNITIES

The Partnerships breakout group, chaired by **Ms. Heidi Hirsh**, U.S. Marine Corps, identified partnership opportunities for DoD that would be beneficial to the management of TER-S in the Pacific Islands region. It was noted that DoD is already engaged in several working partnerships (e.g., through projects at MCBH and KMR-Hilo) and developing an online document repository for TER-S on military lands, which is available through the National Biological Information Infrastructure (http://dodtes.nbii.gov).

NGO representatives and State officials expressed strong interest in partnering with DoD on several initiatives, especially joint research and restoration projects at the regional level. While some initiatives are underway, it appeared that not all participants were equally aware of current DoD work, suggesting the need for better external communication. Recommendations from this session fell into four main areas: early coordination in the planning process, encouraging public cooperation for TER-S conservation, communication between researchers and resource managers, and fostering public awareness.

Early Coordination in the Planning Process

- Engage the public early in the INRMP process.
- Build in a more extensive public comment period for INRMPs.
- List INRMP comment periods on the Hawaii Conservation Alliance web site as well as in the Environmental Notice.
- Seek assistance from agencies with the appropriate technical expertise.

Encouraging Public Cooperation for TER-S Conservation

- Implement additional watershed councils and partnerships that include DoD installations. In particular, DoD should become involved in the Koolau and Waianae watershed partnerships.
- Improve communication between DoD and other State, federal and private agency biologists.
- Develop materials to assist public in NIS eradication at point of sale.

Communication between Researchers and Resource Managers

- Enhance outreach efforts to publicize results of ongoing and past research projects.
- Improve web-based communication of results.
- Increase DoD participation and attendance in local meetings, perhaps by establishing a DoD liaison for the Pacific Islands region.
- Host local DoD research forums, and invite the public, NGOs, and other State and federal agencies to participate.

Fostering Public Awareness

- Publish quarterly/monthly notice of DoD planning processes and activities for each installation in the region.
- Incorporate public awareness of DoD conservation efforts into established events (e.g., Bay Fest, 4th of July celebration), especially targeting children and families.
- Better publicize good news results of research and restoration efforts.
  - Add publication of results as a requirement in all contracts
  - Publish success stories in installation and regional command newspapers
- Improve communication between DoD Natural Resource Managers and Public Affairs Officers (PAOs).
- Provide better access to DoD lands for volunteer efforts and tours highlighting successes.
- Provide DoD community grants to universities, small community groups, and non-profit organizations.
- Provide contact information lists for Natural Resource Managers and PAOs to the Hawaii Conservation Alliance, as well as posting it on the Internet.

8.0 SYNTHESIS AND PRIORITIZATION OF NEEDS

Synthesizing and prioritizing information resulting from breakout group discussions was a primary workshop objective. In this session, participants divided into Aquatic and Terrestrial breakout groups to examine and clarify the top TER-S, ecosystem management, and NIS research, demonstration, and management needs that were identified in earlier sessions. The outcome objective was to further refine and prioritize these needs. Although the two breakout groups took different approaches in accomplishing this objective, each developed a clear list of needs relevant to their respective areas. Following the workshop, a working group further refined and elucidated the top priorities.

8.1 AQUATIC NEEDS

Through a round-robin process led by **Mr. Peter Boice**, DoD Conservation Team Leader/Legacy Program Manager, all participants provided input as to what the top research, demonstration/ validation and management, needs were for aquatic ecosystems in the Pacific Region. Many of these issues were elicited from *Breakout Session I – Aquatic TER-S*. The purpose of Session I was to examine species-specific issues, including basic life history needs, groupings for management purposes, prioritization, and strategies to achieve viability/define a viable population. Group members were asked to weight the cumulative list of priorities using a five-point system. Prioritized outcomes are listed below. The asterisk indicates the top ranked priority per category.

Research

<u>Non-Native Invasive Species</u>

- Assess and inventory existing tools and protocols for effectiveness or new uses to prevent the spread of NIS.*
- Determine and develop tools to prevent introductions, conduct early detection, rapid response (ED/RR), and contain introductions.
- Examine potential for NIS introductions between Okinawa and Guam/Hawaii, including possible pathways for spread/movement due to realignment.
- Gather basic information on biofouling of ship hulls.
- Develop eradication methods for California grasses in wetlands.

<u>Ecosystems</u>

- Develop methods to detect ecosystem phase shifts and their synergistic effect on TER-S.
- Understand the trophic relationships that exist between NIS and TER-S.
- Knowledge of altered hydrology and its effects on ecosystems.
- Effective methods to clean up UXO in marine environments.

Threatened, Endangered, and At-Risk Species

- Conduct basic surveys and biological knowledge for streams on Guam, aquatic caves, Inner Apra Harbor, and the upper reaches of Hawaii streams.
- Assess acoustic impact of training on TER-S.
- Carry out research on dietary needs of Hawaii waterbirds and the Micronesian green turtle.
- Determine the feasibility of how to and what species to use for coral transplantation.
- Determine the feasibility and cost effectiveness of remote sensing to enforce anti-poaching regulations.
- Define the minimum viable population size for various species and their resiliency when pressured.
- Assess the effects of military training on TER-S habitats.

Demonstration

- Adapt existing technologies to eradicate suites of NIS in a specified area (i.e., test site) in both marine and freshwater systems.*
- Improve effectiveness/efficiency of NIS control of algae/seaweed.
- Develop new technologies for feral ungulate control.
- Use of low impact development/green infrastructure to support realignment.
- Use remote sensing technology to determine aquatic health.

Management

- Develop practices and protocols for prevention of NIS introductions, ED/RR, and containment.*
- Reestablish native plant communities at the watershed level.
- Standardize inventory procedures acceptable to DoD and other trustees.
- Add clauses to contracts to standardize policies regarding NIS (e.g., for restoration projects).
- Resurvey Pearl Harbor for changes to baseline.

Problems associated with NIS and how best to deal with those problems was a major theme throughout the discussion. Of the top 15 identified priorities, nine dealt directly with NIS. The need to provide both funding and mechanisms to address regional NIS issues was paramount, as was the need to deal with the issues collectively and in partnership.

8.2 TERRESTRIAL NEEDS

Led by **Dr. John Hall**, SERDP/ESTCP Sustainable Infrastructure Program Manager, each terrestrial breakout group participant was first allowed to provide their top priority issues for research, management, and demonstration needs from the earlier sessions. To narrow the collective list of priorities by area, each participant then identified his/her top three priorities for each area and his/her top three ideas across all areas. Following is a prioritized list of all identified priorities. The asterisk indicates the top ranked priority per category.

Research

Non-Native Invasive Species

- Develop an inanimate BTS lure or bait.
- Develop an aerial broadcast for BTS toxicant
- Develop vertebrate control methods/techniques.
- Determine impacts of ungulates on water quality/quantity and erosion.
- Research the thresholds of population level of an NIS in an organismal community such that community still functions.
- Develop control methods for parasitoid wasps and flies.
- Research the ecological and economic consequences of loss of NIS from altered systems for native species (e.g., pollination).
- Research enzymes that can cause physiological disruption of NIS grasses, designer enzymes for bio-control.
- For highest-priority NIS plants, investigate reproductive biology and regulating mechanisms in native environment.
- Carry out research in support of pesticide registrations.
- Research the microbial control mechanisms of vertebrate NIS

Ecosystems

- Develop ecological approaches to break the grass/wildfire cycle.*
- Carry out trend monitoring for native and mixed native/non-native ecological systems associated with DoD lands.
- Determine the fire ignition probability from military sources (e.g., munitions).
- Define indicators for ecological change.

Restoration

- Research methodologies for restoring dry forest areas.

- Develop BMPs for outplanting to improve success (e.g., phased plantings, appropriate habitats, and associates).

Threatened, Endangered, and At-Risk Species

- Ascertain the effectiveness of native and non-native pollinators.
- Determine the impacts of noise from military operations (e.g., helicopter wash) on TER-S (e.g., fruit bats, Marianas crow).

Demonstration

Non-Native Invasive Species

- Broadcast aerial rodenticide.
- Install vertebrate excluder fences in dry and wet habitats, including those targeting small rodents as well as larger mammals
- Research emerging technologies for ungulate control.
- Use LIDAR and hyperspectral imaging to quantify the distribution, impacts, and dynamics of NIS.
- Use dogs and other chemosensory methods to detect TER-S and NIS.
- Research slug/snail toxicants with goal of registration.
- Eradicate and/or exclude ants.
- Streamline quarantine treatment for military vehicles (i.e., improving process efficiency).

Restoration

- Develop phased approach to native habitat restoration.*

Fire

- Carry out green stripping for fire breaks.
- Perform large-scale grass control using a combination of fire and spraying.
- Adaptation of fuels models.

Technology

- Detect nocturnal animals using night-vision equipment.
- Determine the transferability of autonomous recording units from mainland to the Pacific Islands region (needed given the extreme variation in species acoustics, and extremely moist conditions.

- Determine the transferability of acoustic detection and tracking systems for bats from the mainland for Pacific Island species.

Management

- Refine objectives and develop performance metrics for control of vertebrates (rodent/ungulates/deer/BTS).*
- Restore non-native grass systems to their original status (including dry forests)
- Develop rapid response techniques for NIS.
- Develop detection methods for incipient NIS and TER-S (rare species).
- Write landscape-scale management plan for pigs.
- Perform brown tree snake quarantine.
- Develop information exchange databases targeting gray literature related to restoration for land managers.
- Carry out wet forest restoration.
- Educate nursery industry.

Problems associated with habitat restoration (especially native dry forests) and with controlling or eradicating non-native animal species (rodents, BTS, ungulates, pigs) were major focal points throughout these discussions. Dealing with these issues will be complex, and will require multi-faceted approaches. It is likely that work on these topics could potentially take place concurrently across the research/demonstration/management demarcations.

8.3 SYNTHESIS OF AQUATIC AND TERRESTRIAL PRIORITIES

The concepts captured in the table and described in the text below provide a more detailed summary of the current high-priority issues as revealed during workshop discussions (see Section 4-8 for specific research, demonstration, and management objectives).

Table 1: Highest Priority Aquatic and Terrestrial Information Gaps

Aquatic	Terrestrial
Biological inventory, recent status trends, ecological function, and military impacts for Pearl Harbor, inner Apra Harbor, freshwater streams on Guam and upper reaches on Hawaiian Islands, and aquatic caves	Methods for and phasing of native habitat restoration, especially dry forests
General approaches for NIS early detection, rapid response, pathway assessment, and control methods in both freshwater and marine environments	Ecological approaches to breaking the non-native grass-wildfire cycle
NIS potential for spread (pathway assessment) between Okinawa and Guam and Hawaii (due to military force realignment)	Brown tree snake control methods
Biofouling of ship hulls as a pathway for NIS introduction	Management of invasive vertebrates, especially rodents and ungulates
Management of NIS algae and seaweed	General approaches for NIS early detection and rapid response

NIS control, especially ungulates, and habitat restoration within a watershed context	General detection methods for TER-S
Non-linear (threshold) responses to ecosystem perturbations and their effects on TER-S	
Remote sensing technologies for aquatic health assessment	
Standardization of NIS policies and management procedures and NIS/TER-S regional inventory protocols	

Among these information gaps, invasive species issues, ecological system functioning, restoration-related issues, and partnerships emerged as key priority areas.

8.3.1 INVASIVE SPECIES

Because the Pacific Islands are among the most isolated land masses on earth and have high levels of endemism, preserving native ecosystems from non-native invasive species (NIS) is of utmost importance. With an average of two newly introduced species annually developing invasive characteristics, it is imperative that the introduction and spread of NIS be controlled.

General approaches for NIS early detection, rapid response, pathway assessment, and control methods in both freshwater and marine environments. Once identified and established, NIS oftentimes become difficult to control; therefore, techniques and tools must be developed to effectively contain and eradicate high-risk NIS aquatic species before they become problematic. First and foremost, there is a need to identify and assess potential pathways and develop state-of-the-art best management practices (BMPs), approaches, tools, and indicators to prevent introduction, especially through the expanded implementation of coordinated early detection/rapid response (ED/RR) (e.g., remote sensing/monitoring for biosecurity) techniques. Combating NIS in freshwater and marine systems can prove additionally difficult due to transfer and establishment mechanisms. Equipment can be moved from place to place without personnel having knowledge that attached organisms are present. These organisms, which can persist over long periods of time, may then be transferred and spread at alarming rates. Therefore, an educational component and facilitating fiscal mechanism must be included to ensure that both military personnel and the general public are familiar with issues related to the introduction and spreading mechanisms of NIS in aquatic and marine ecosystems.[23]

General approaches for NIS early detection, rapid response, and control methods in terrestrial environments. One of the most important aspects to controlling NIS is ED/RR, which encompasses detecting NIS upon arrival (before their inadvertent or purposeful release into the environment), identifying possible pathways of invasion and, if NIS have already been introduced into the system, ensuring that they do not spread outside the immediate invasion area. There are several techniques for each of the phases of ED/RR that have met with varied success. A general survey of these techniques across agencies needs to be conducted to determine the most successful measures. In some cases, these approaches may be modified slightly to enhance their effectiveness, but improvements are needed to not only enhance the state of the art, but also

[23] Education should include an Office of the Secretary of Defense letter to commands/services that supports and endorses NIS ED/RR at the ground level. Financial issues related to ED/RR include timely response capability, endurance across fiscal years, and shared agency responsibility/authority. An existing example is the interagency fire model, which could be adapted to support existing mechanisms (e.g., invasive species committees).

to develop more effective practices to stop the invasion of non-native species throughout the region. In terrestrial systems, West Nile virus, fire ants, and eucalyptus rust are the most critical ED/RR management issues at this time.

NIS potential for spread (pathway assessment) between Okinawa and Guam and Hawaii (due to military force realignment). As a result of the anticipated increase in military ship traffic associated with base realignment and closure (BRAC) plans, there is the possibility of increased introductions of NIS both from Okinawa to Guam and from Guam to the Hawaiian Islands. These introductions can result from both military and commercial shipping vectors, as well as from personnel transport. Therefore, efforts are needed to assess (1) potential transportation vectors, (2) types of organisms that may travel or "hitchhike" using these vectors, and (3) all mitigative avenues that may inhibit NIS from spreading via these invasion pathways.

Biofouling of ship hulls as a pathway for NIS introduction. Biofouling of ship hulls represents a potential pathway for NIS introductions. With recent BRAC plans to transfer operations across the Pacific, there is a need to determine the fouling mechanisms, rates, and types of organisms most likely to pose an NIS threat. Basic research on the potential magnitude of transfer, using the surface of the hull to represent the colonizable surface, is a research question now being examined by scientists worldwide. One particular assessment mechanism is to inspect ship hulls in drydock to assess the species and densities of organisms existing on the hull. Once the organisms and mechanisms of fouling are identified, research needs to be conducted to determine the types of antifouling agents needed to curb the risk of transfer, while ensuring the least environmental impact to native organisms.

Management of NIS algae and seaweed. Management of NIS algae and seaweed is vital to proper ecosystem function in both marine and freshwater systems (algae). These organisms often colonize and out-compete native organisms for light, space, and food resources, while smothering corals and other sessile plants and animals. They often displace and shift food webs, causing anoxic conditions in freshwater systems and phase shifts from coral to invasive algae dominance with loss of diversity and associated loss primary production. These sometimes microscopic organisms are often difficult to identify in the initial stages of invasion but, once established, are highly difficult to control. Although their vector of transport is suspected to be through ballast and hull fouling, there exists little quantitative data on their current distributions and modes of reproduction and dispersal. Basic research is needed on prevention and eradication mechanisms for invasive algae and seaweeds.

Standardization of NIS policies and management procedures and NIS/TER-S regional inventory protocols. Current protocols and policies for managing NIS in the Pacific Islands region are often insufficient, and many differ across agencies. There is a need to develop new approaches to address current gaps, and these must include an implementable system of ED/RR and an educational component so that military personnel can better detect, report, control/treat, and assess (monitoring efficacy and rapid response procedures/facilities) efforts. Similarly, there is a need to standardize and streamline existing practices and policies across federal and state agencies. This process should begin with a thorough inventory and assessment to existing tools and protocols to determine their effectiveness and cost efficiency in prevention and/or control of suites of marine and freshwater NIS.

Brown tree snake control methods. The brown tree snake (BTS)—a native of Indonesia, New Guinea, the Solomon Islands, and Australia—has caused power outages, killed pets, bitten small children, damaged agricultural areas, and caused the extinction of several species native to Guam. Because of high rates of endemism in the Hawaiian Islands and the high rate of ship and air traffic between Guam and Hawaii, there is significant concern that BTS may be inadvertently transported to the Hawaiian Islands. In 1990, the U.S. Congress included a section in the Nonindigenous Aquatic Nuisance Prevention and Control Act authorizing a cooperative program to control BTS outside of its historic range. Representatives from the Northern Mariana Islands, Guam, the State of Hawaii, and the departments of Defense, Agriculture, Commerce, and Interior formed the control committee to develop a plan to help control BTS. This plan includes implementation of several short- and long-term techniques to help control the spread of BTS to Hawaii and possibly the mainland United States. These techniques have met with varied success. Key information gaps are understanding which broad-scale control techniques have the greatest potential for reducing BTS populations, and how control methods currently in use can best be enhanced.

Management of invasive vertebrates, especially rodents and ungulates. Invasive vertebrate species have been degrading Hawaiian ecosystems since their introduction. As one would expect, the range of impacts to the ecosystem vary from damage to native flora through predation, competition, and habitat degradation to the disruption of ecological cycles such as nutrient transfer and food web dynamics. For example, non-native ungulates have been responsible for degrading and fragmenting much of the native dry forests in several tracks across the Hawaiian Islands, as well as reducing native plant diversity, compacting soil, changing nutrient and sediment dynamics across freshwater systems, and degrading the native ecosystem to such a degree that it is more susceptible to the invasion of non-native plant species. Invasive rodents also have caused damage across native ecosystems by preying on native birds and other pollinators. In addition to the loss of avian diversity, loss of pollinators has severely impacted the diversity of native plants reliant solely on endemic pollinators for survival. Because of this range of impacts, it is imperative that steps be taken to help control and/or extirpate populations of these non-native vertebrates. Measures have already been taken to help reduce their impacts (through exclusion fencing, biocontrol, and chemical toxicants), but success to date has been limited. Research is needed to determine how best to adapt and/or implement techniques that target small animals, mouflon sheep, deer, and blackbuck antelope, as well as to assess the impacts of these techniques on ecosystem structure and function. Further, clear objectives for control and performance metrics for success at a meaningful scale should be established.

8.3.2 ECOLOGICAL SYSTEM COMPOSITION, STRUCTURE, AND FUNCTION

Ecosystems in the Hawaiian archipelago are unique, and not all are well-understood. At many sites, basic inventory information is lacking. In certain cases, the distribution of native species that are sensitive to disturbance and NIS aquatic species that may be co-located are unknown.

Biological inventory, recent status trends, ecological function, and military impacts for Pearl Harbor, inner Apra Harbor, freshwater streams on Guam and upper reaches of Hawaiian Islands, and aquatic caves. To support resource management, information is needed on existing

flora and fauna, population trends in previously surveyed and impacted areas, and status of basic ecological function. To acquire this information, baseline studies need to be conducted in the inner Apra Harbor, streams on Guam and the upper reaches of the Hawaiian Islands, and in aquatic caves. A reassessment of resources in Pearl Harbor, Oahu, also is needed to determine floral, faunal, and ecological function changes that have occurred since the prior baseline survey that was completed in the 1970s.

A related need is determining the ecological function of the above-stated ecosystems and how military activities alter their ecological processes. Little is known about the impact of training activities on aquatic ecosystems in the Pacific Islands region (both freshwater and marine). Understanding these underlying processes and responses to training activities can enhance natural resource management and mission planning.

Remote sensing technologies for aquatic health assessment. Many of the aquatic ecosystems on the Hawaiian Islands and Guam are in areas difficult to access. Because of this, little is known about the status of these systems and whether TER-S reside there. Current technology has the capability to remotely assess ecosystems for an array of on-the-ground resources and, from there, the relative health of the system. For example, the upper reaches of many streams in Hawaii and Guam are located near the summit of volcanic peaks in terrain that is inaccessible by foot or vehicle. Many important TER-S and their associated habitats may exist in these systems. Through the use of aircraft-mounted instruments, a survey to determine probability or existence of TER-S habitats and relative health may be possible. Many institutions are now using infrared technology, LIDAR, and side-scan radar to help assess remote locations. Research is needed to adapt these and other technologies for use in aquatic systems.

General detection methods for TER-S. There are currently no standardized methods to detect and identify TER-S across large tracks of land. A standardized methodology to detect TER-S on landscapes across agencies and across species, would help land managers more effectively manage TER-S populations. As with aquatic systems, the use of remote sensing to detect small populations of rare species of TER-S is highly desirable. With the use of remote sensing technologies, managers would be able to survey remote areas that, since they are mostly undisturbed, may support TER-S. Also, there are several technologies available that, if slightly modified, could potentially detect TER-S more easily and affordably than currently used methods. Transfer of technologies from other locales as well as from other disciplines is needed.

Non-linear (threshold) responses to ecosystem perturbations and their effects on TER-S. Pacific Island ecosystems are undergoing rapid change as a result of encroachment, climate change, NIS, and other factors. The response of ecosystems and their associated fauna do not necessarily follow a linear dose-response path so that, oftentimes, there is little or no change until a single event tips the delicate balance. The amount of change an ecosystem can withstand before structure, composition, or fauna may be altered irreversibly varies from system to system and even from habitat to habitat within a particular area, and it is often difficult to predict what that tipping point is until the threshold has been exceeded. Research is needed to determine thresholds for perturbations that native systems can withstand and recover from, as well as the amount of habitat loss or change that the associated TER-S residing in these ecosystems can tolerate (i.e., typical TER-S responses).

Ecological approaches to break the grass/wildfire cycle. Because of the rapid and widespread expansion of NIS grasses throughout the Pacific Islands and the resulting increase in fuel loads, wildland fire now poses a significant threat to native habitats, particularly dry forest systems, as well as the health and safety of urban areas. The non-native grass/wildfire cycle is currently driving the extirpation of native species and facilitating the expansion of other NIS. As a result of damage to the natural biota and the danger to humans associated with these fires, military training, and therefore U.S. military preparedness, has been hampered. Breaking the invasive species/wildfire cycle is among the greatest challenges facing DoD land managers and researchers in the Pacific Islands region today. Furthermore, even in the absence of fire, competitive non-native grasses have been shown to reduce growth and recruitment of native species and alter ecosystem processes. Fire models must be adapted to the region to predict fire hazards/severity (i.e., behavior). Elements of the models should include, but are not limited to, fuel loading, fuel moisture dynamics, live/dead ratio, and microclimate and weather. Further, the effects of wildfire on the physical and biological attributes of the land must be understood to support efforts to mitigate impacts on the landscape and watershed. Of particular importance to DoD are self-sustaining means to prevent and control fire in highly vulnerable areas (e.g., military training areas). Techniques might include creating barriers to prevent the rapid spread of fire (e.g., green stripping) and developing control and restoration techniques to shift from grass-dominated to woody-dominated species, thereby reducing fuel loads.

8.3.3 RESTORATION

In support of restoring degraded aquatic and terrestrial systems throughout the Pacific Islands region, there is a need both for historical baseline information, and for information on the impacts to and restoration potential for degraded areas on the surrounding watershed (e.g., through the flux of nutrients, sediments, and contaminants). Such information can facilitate the establishment of meaningful restoration goals prior to project implementation. Improved restoration techniques and approaches also are needed.

Methods for and phasing of native habitat restoration, especially dry forests. Forests provide diverse habitat for many TER-S in the Pacific Islands region. Much of Hawaii's dry forests, in particular, have been significantly degraded or fragmented. Tropical dry forests are among the rarest and most diverse ecosystems in the world, with only 10% still remaining. The decline in tropical dry forests has been associated with purposeful deforestation for agricultural production as well as less intense land-cover changes that are incidental to other land uses (e.g., logging, grazing, military activities). To establish restoration objectives, historical baseline information on the composition, structure, and function of dry forest vegetation types and how these have been altered by legacy land uses is needed. Models of the potential distribution of such forests and the current condition of extant forests also are needed to understand the scope of, and opportunities for, restoration. To overcome barriers to dry forest restoration/native succession, methods must be developed that account for the appropriate phasing of restoration steps and mitigation of the grass/wildfire cycle. Once demonstrated, such phased approaches could then be expanded to other systems.

NIS control, especially ungulates, and habitat restoration within a watershed context. Because of development, feral ungulates, deforestation, and a host of other perturbations, Pacific Island region streams and their water quality have been gravely impacted. Fluxes of sediments, nutrients, and other contaminants from the land have not only degraded stream ecosystems, but also the near-shore marine environment. There is a need to develop holistic approaches to watershed restoration and to determine baseline conditions within these watersheds. This baseline information should include sedimentation rates, water quality, and biological diversity as well as information regarding episodic events (e.g., tropical storms), changing water levels, climate change, and current and future military activities. Once this information has been established, watershed-based restoration methods need to be established. Restoration plans should consider downstream and surrounding landscape effects. Since many restoration projects are planned on a stream-by-stream basis, the challenge to watershed restoration is ensuring the incorporation and success of many projects to target larger but specific watershed-level problems. Post-restoration data also are needed to identify those indicators best suited to determine restoration success.

9.0 CONCLUSIONS AND RECOMMENDATIONS

By bringing together relevant managers and researchers from various sectors, the *Pacific Islands Region TER-S Workshop* facilitated communication and, it is hoped, created a platform for future research and management action that benefits both TER-S and sustainability of the military testing and training mission. The concepts captured below provide a thematic overview of key workshop outcomes.

9.1 AQUATIC

- Ecological System Composition, Structure, and Function: Ecosystems in the Hawaiian archipelago are unique, and not all are well-understood. Of particular concern regionally is the integrity of inland aquatic systems. At many sites, basic inventory information is needed related to stream ecosystem management. In certain cases, the distribution of native freshwater aquatic species that are sensitive to disturbance and NIS aquatic species that may be co-located are unknown.

  To better understand species occurrence and biology, researchers and managers must not only collect these data, but also standardize inventory and monitoring systems for cross-agency application. Additionally, quantification of the ecological function, structure, and dynamics of these systems is needed throughout the Pacific, specifically in the upper reaches of streams on the Hawaiian Islands, as well as in streams, and the Inner Apra Harbor and caves on Guam. Information on the impact of military activities on these systems and their functioning is necessary for installation natural resource management and mission planning.

  Information on feral ungulate control is also of concern, especially data that quantify impacts of ungulate presence and control on aquatic systems, including water quality and quantity, erosion, pathogen loads (e.g., *Leptospirosis*), and biota response. These data are integral to ensure that aquatic systems are maintained.

- Restoration: Degradation of stream ecosystems and watersheds ultimately may lead to negative impacts on sensitive near-shore marine ecosystems through the fluxes of nutrients, sediment, and contaminants. In the Pacific Islands, varying amounts of data have been collected on baseline conditions and impacts of the surrounding watershed.

  Data are needed on pre-restoration conditions in order to develop realistic yet comprehensive objectives to restore degraded areas to more functional system conditions. Information pertaining to sedimentation rates, water quality, and biological diversity is of particular interest.

  Further, because restoration techniques vary widely from system to system, ranging from passive installation of BMPs to the active construction of stream channels through the natural design process, additional information regarding episodic events, changing water levels, climate change, and current and future military activities are needed. This information can then be used to better plan and implement full scale restoration projects.

Post-restoration data also are needed to identify those indicators best suited to determine restoration success, thus facilitating the development of metrics for success.

- Invasive Species: Island systems sustain a high level of ship traffic. Because of this, the influx and spread of aquatic NIS is significant and continually evolving. In the Pacific Islands, this situation is of particular concern to DoD due to the anticipated increase in military ship traffic associated with base realignment and closure (BRAC) plans.

  Once identified and established, NIS oftentimes become difficult to control; therefore, techniques and tools must be developed to effectively contain and eradicate high risk NIS aquatic species before they become problematic. First and foremost, a need exists to identify and assess potential pathways (specifically from Okinawa to Guam and Hawaii) and develop state-of-the-art BMPs, approaches, tools, and indicators to prevent introduction, especially through the expanded implementation of coordinated early detection/rapid response (ED/RR) (e.g., remote sensing/monitoring for biosecurity) techniques. These must include both an educational component and facilitating fiscal mechanism.[24]

  In addition to developing new approaches, existing tools and protocols should be inventoried and assessed for effectiveness and cost efficiency in eradicating suites of marine and freshwater NIS, and a system of early detection/ rapid response (ED/RR) needs to be implemented. This system must include an educational component so that military personnel can better detect, report, control/treat, and assess (monitoring efficacy and rapid response procedures/facilities) efforts.

9.2 TERRESTRIAL

Ecological System Composition, Structure, and Function: Due principally to vegetation damage, vertebrate species are having significant and detrimental impacts to terrestrial systems throughout the Pacific region.

There is a need to better understand the impacts of vertebrates on terrestrial ecosystems, especially because of the vegetation damage and ecosystem alteration caused by non-native vertebrate herbivores. Clear objectives for vertebrate control and performance metrics for success at a meaningful scale relevant to other stakeholders (opportunities for transferability of approaches/standards from other agencies to DoD) should be established. This concept may be achievable through support for a regional ungulate control coordinator (there is already a State ungulate control coordinator, though not a military counterpart).

Demonstration of vertebrate exclusion in wet and dry habitats is needed to provide management information for effective engineering of this approach. Impacts of these

[24] Education should include an Office of the Secretary of Defense letter to commands/services that supports and endorses NIS ED/RR at the ground level. Financial issues related to ED/RR include timely response capability, endurance across fiscal years, and shared agency responsibility/authority. An existing example is the interagency fire model, which could be adapted to support existing mechanisms (e.g., invasive species committees).

techniques on ecosystem structure and function must be assessed. Efforts should be focused on small animals, mouflon sheep, deer, and blackbuck antelope. Implementation of exclusion techniques have been successfully demonstrated in New Zealand, and could be adapted for demonstration in the Pacific Islands region.

- Restoration: Forests provide diverse habitat for many Pacific Island TER-S, yet forests in general have been declining and much of Hawaii's dry forests, in particular, have been significantly degraded or are now gone. Dry forest restoration goals (i.e., desired, achievable end points) need to be ascertained through the study of historical baseline data on terrestrial systems (structure, function, composition) as affected by legacy land use, characterization to assess existing status of community, and hypothetical distribution of forests based on modeling.

  Techniques must be developed to overcome barriers to dry forest restoration/native succession (e.g., NIS). This may best be accomplished by devising a phased approach to restoration (i.e., using a time-phased methodology, beginning with common species then inter-planting at-risk species, and finally listed species). Once tested, this approach could then be expanded to other systems.

  Existing conceptual models should be used to assist in this approach to improve dry forest restoration methodologies.[25] Similarly, a phased approach to restoration in wet or mesic forests needs to be demonstrated to establish workable management techniques.

- Wildland Fire: Because of the rapid and widespread expansion of NIS grasses throughout the Pacific Islands and the resulting increase in fuel loads, wildland fire now poses a significant threat to native habitats, particularly dry forest systems.

  Ecological approaches to break the grass/wildfire cycle are needed. Fire models must be adapted for the Pacific Islands region to predict fire hazards/severity (behavior). Elements of the models should include, but are not limited to, fuel loading, fuel moisture dynamics, live/dead ratio, and microclimate and weather. Of particular importance to DoD are self-sustaining means to prevent and control fire in highly vulnerable areas (e.g., military training areas).

  Techniques should include creating barriers to prevent the rapid spread of fire (e.g., green stripping), and developing control and restoration techniques to shift from grass-dominated to woody-dominated species, thereby reducing fuel loads.

- Invasive Species: Because the Pacific Islands are among the most isolated land masses on earth and have high levels of endemism, preserving native ecosystems from non-native invasive species is of utmost importance. With an average of two newly introduced species annually developing invasive characteristics, it is imperative that the introduction

[25] One attendee suggested that a long-term research test site, similar to SEMP (SERDP Ecosystem Management Project, https://www.denix.osd.mil/denix/Public/Library/SEMP/semp.html) or DCERP (SERDP's Defense Coastal/Estuarine Research Project, http://www.serdp.org/research/CS/CS-1413.pdf) should be considered.

and spread of NIS be controlled. As with aquatic systems, ED/RR systems need to be implemented for terrestrial NIS to encompass education, detection, reporting, control/treatment, and assessment.

Of specific concern to many participants was the lack of effective methods for brown tree snake (BTS) control. Research on broad-scale BTS control techniques is required because of the damage the snakes cause to ecosystems, commerce, and human health in Guam, and the potential to have the same effects if introduced to Hawaii. New means to reduce BTS populations (e.g., inanimate lure, aerial broadcast) must be developed in order to effectively reduce BTS populations at a scale large enough to be meaningful.

Similarly, rodent control is essential in protecting TER-S and restoring habitats. Demonstrations of the aerial broadcast of rodenticide, including monitoring (post-EPA registration) are also needed to achieve rodent management recommendations and acceptance of rodenticides.

In terrestrial systems, West Nile virus, fire ants, and eucalyptus rust are the most critical ED/RR management issues at this time. Detection strategies and techniques for incipient NIS and TER-S, especially targeting small populations and rare species, should be implemented. Transfer of detection technologies from the mainland (e.g., acoustics, chemosensors), as well as from other disciplines (e.g., munitions) is needed.

9.4 PARTNERSHIPS

Partnering transcends aquatic and terrestrial habitat boundaries. The importance of local-level partnerships and information sharing cannot be overstated, especially since the lines of communication between the military, state and federal agencies, and the regional NGO community can be weak. For example, although many of the workshop participants have for years worked on TER-S issues throughout the Islands, some had never before met. While partnerships do exist, including several local watershed organizations, more open communication and strengthened partnerships are needed not only to share information and data, but also to help foster joint research, conservation, and management projects. Towards that end, DoD should consider increasing its participation in regional partnership efforts, such as joining the Hawaii Conservation Alliance, and actively engaging State and NGO groups when updating and implementing various management plans.

9.5 SUMMATION

Advancing research priorities and using resulting information to better manage listed and at-risk species offers a significant opportunity to benefit TER-S populations in the future. As a direct result of information gathered at this workshop, the Legacy Program has funded five proposals and SERDP has developed two FY2008 Statements of Need: **MANAGING AND RESTORING THE DRY FOREST ECOLOGICAL SYSTEM IN THE PACIFIC ISLANDS** and **IMPACTS OF MILITARY ACTIVITIES AND INVASIVE SPECIES ON PACIFIC ISLAND FRESHWATER AND NEAR-SHORE MARINE ECOSYSTEMS**.[26]

[26] See http://www.serdp.org for more information.

Given the workshop's productive nature and positive outcomes, Legacy Program officials have suggested that a follow-on workshop take place in 2009. The intent of a follow-on workshop would be to evaluate activities resulting from the recommendations captured in these proceedings, to allow for any mid-course corrections, and to update, as necessary, the blue print for this investment strategy.

While no one group or agency can undertake all the actions enumerated in this document, recommendations captured are relevant to many stakeholders. Therefore, these proceedings should be viewed as a source document when prioritizing annual planning and resource allocation activities, and should stimulate invigoration of old partnerships and the launching of new ones. Overall, it is hoped that workshop outcomes will prove valuable for multiple interested stakeholders throughout the Islands for the next several years.

###

Appendix A: Workshop Attendee List

Name	Title	Organization	State
Ashfield, Patrice	Biologist	US Fish and Wildlife Service	HI
Banko, Paul	Station Leader	US Geological Survey, PIERC	HI
Boice, Peter	Director, Conservation Program	DoD Legacy Program	VA
*Brown, Bill	Director	Bishop Museum	HI
Buckman, Art	Natural Resource Manager	US Air Force	HI
Buermeyer, Karl	NEPA Administrator	HI Army National Guard	HI
Bustos, Norma	Wildlife Program Specialist	Hawaii DLNR, Division of Forestry and Wildlife	HI
Campbell, Earl	Pacific Invasive Species Coordinator	US Fish and Wildlife Service	HI
Cody, Elizabeth	Botanist	Hawaii DNLR	HI
Cofrancesco, Al	Technical Director, Environ. Engineering and Sciences	US Army Corps of Engineers (ERDC-EL)	MS
Costales, Pat	Oahu Branch Manager	Hawaii DLNR, Division of Forestry and Wildlife	HI
Dalsimer, Alison	Conservation and Natural Resource Specialist	HydroGeoLogic, Inc. (HGL)	VA
Davidson, Kristine D.	Program Director	University of Hawaii	HI
Drigot, Diane	Senior Natural Resources Management Specialist	US Marine Corps	HI
Duffy, David	Chair, Dept of Botany	University of Hawaii	HI
Eldredge, Lu	Invertebrate Zoologist	Bishop Museum	HI
Fox, Mark	Director of External Affairs	The Nature Conservancy	HI
Friese, Dan	Natural Resource Specialist	US Air Force, AFCEE	TX
Funk, Jen	Postdoctoral scholar	Stanford University	CA
Gorman, Lew	DoD Liaison	US Fish and Wildlife Service	VA
Graham, Krista	Resource Management Specialist	NOAA/Fisheries/Pacific Islands Office	HI
Greenlee, Dawn	Biologist	US Fish and Wildlife Service	HI
Gulko, Dave	Aquatic Biologist IV Coral Reef Ecologist	Hawaii DLNR, Aquatic Resources Division, Coral Reefs	HI
Hall, John	Program Manager	DoD SERDP and ESTCP	VA
Harrison, Sky	Content Manager	US Geological Survey, Pacific Basin Information Node (NBII)	HI
Hirsh, Heidi	Natural Resource Manager	US Marine Corps	VA
Howarth, Frank	L.A. Bishop Distinguished Chair of Zoology	Bishop Museum	HI
Hughes, Flint	Ecosystem Ecologist	Forest Service, Institute of Pacific Islands Forestry	HI
Jacobi, Jim	Research Botanist	US Geological Service, PIERC	HI
Javier, Arthur	Conservation NRFA	Hawaii Army National Guard	HI
Jones, Eugene C.	Researcher	California State University, Fullerton	CA

Kauffman, Boone	Institute Director	Forest Service, Pacific Southwest Region	HI
Kennedy, Randy	Natural Areas Program Manager	Hawaii DLNR, Division of Forestry and Wildlife	HI
Koob, Greg	Biologist	USDA, Natural Resource Conservation Service	HI
*Lee, Major General R.	Adjutant General	Hawaii Army National Guard	HI
Leonard, David	Wildlife Biologist	Hawaii DNLR, Division of Forestry and Wildlife	HI
Mallory, Jane	Natural Resource Specialist	DoD Legacy Program - CTR	VA
Mansker, Michelle	Natural Resource Manager	US Army	HI
McBride, Jenness	Wildlife Biologist	US Fish and Wildlife Service	HI
Mehrhoff, Loyal A.	Chief, Biological Resource Management Division	National Park Service	CO
Mikulina, Jeff	Director	Hawaii Chapter of Sierra Club	HI
Montgomery, Anthony	Aquatic Biologist	Hawaii DNLR, Division of Aquatic Resources	HI
Orzetti, Leslie	Consultant	HGL	VA
Pangelinan, Arlene	ESA Specialist	NOAA/Fisheries/Pacific Islands Office	HI
Pelleteri, Sara	Biologist	Hawaii DAR	HI
Pepi, Vanessa	Fish and Wildlife Biologist	US Navy	HI
Polhemus, Dan	Director	Hawaii DLNR, Aquatic Resources Division	HI
Puttock, Chris	Director	Hawaii Conservation Alliance	HI
Rice, Veronica	Meeting Coordinator	HGL	VA
Robotham, Michael	Tropical Technology Specialist	USDA, Natural Resource Conservation Service	HI
Russell, Christa	Biologist/ botanist	US Fish and Wildlife Service	HI
Sailer, Dan	Oahu TNC Preserves	The Nature Conservancy	HI
Schwartz, Lorri	Natural Resource Specialist	US Navy, NAVFAC	DC
Shepard, Alicia	Associate Conservation Specialist	HGL	VA
Shultz, Gina	Assistant field supervisor	US Fish and Wildlife Service	HI
Smith, Barry	Director	University of Guam	Guam
Sutterfield, Tim	Natural Resource Specialist	US Navy, PACDIV	HI
Swift, Katie	Biologist	US Fish and Wildlife Service	HI
Wald, Jonathan	Natural and Cultural Resource Manager	US Air Force	Guam
Wescom, Robert	Natural Resource Manager	US Navy, NAVCOM	Marianas
Woodson, William	Consultant	HGL	MD
*Young, Peter	Director	DLNR, State Cabinet Member for Gov. office	HI
Ziegler, Marge	Executive Director	Conservation Council for Hawai'i	HI

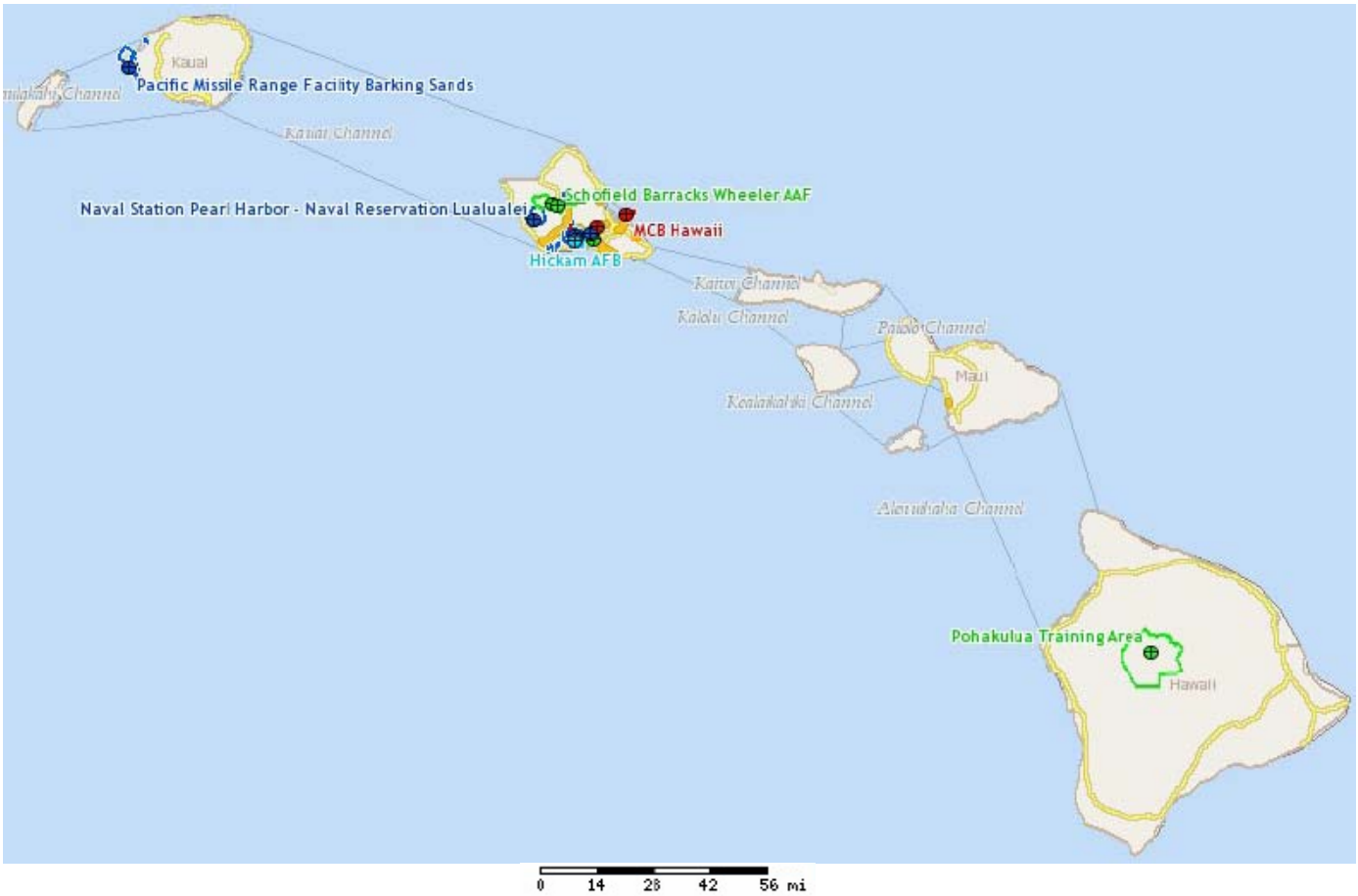
* plenary speaker

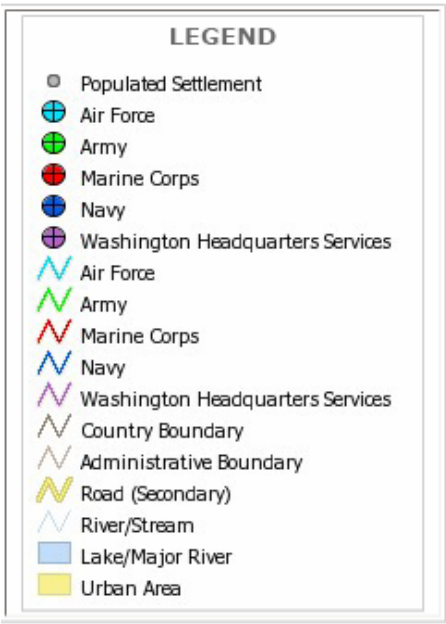
Appendix B: Hawaii Group Discussion, National Symposium

- Marine Corps Priorities
    - o Invasive species control (e.g., fountain grass)
    - o Feral Ungulate Control
    - o Prevention of Invasive Species Introductions
    - o Population Viability Analyses
    - o Defining Optimal Habitats and Carrying Capacity
    - o Quantitative Methods to Define Success of Management Approaches
- USFWS Priorities
    - o Landscape Analysis of Resources
    - o Identify Conservation Priorities
    - o Restoration and Stabilization of Habitat
- Forest Service Priorities
    - o Breaking invasive species, wildfire cycle
    - o Experimental Forest on Big Island
- University of Hawaii Priorities
    - o Limitations in Research Integration
    - o Problem-Solving Science to Address Specific Questions
    - o 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

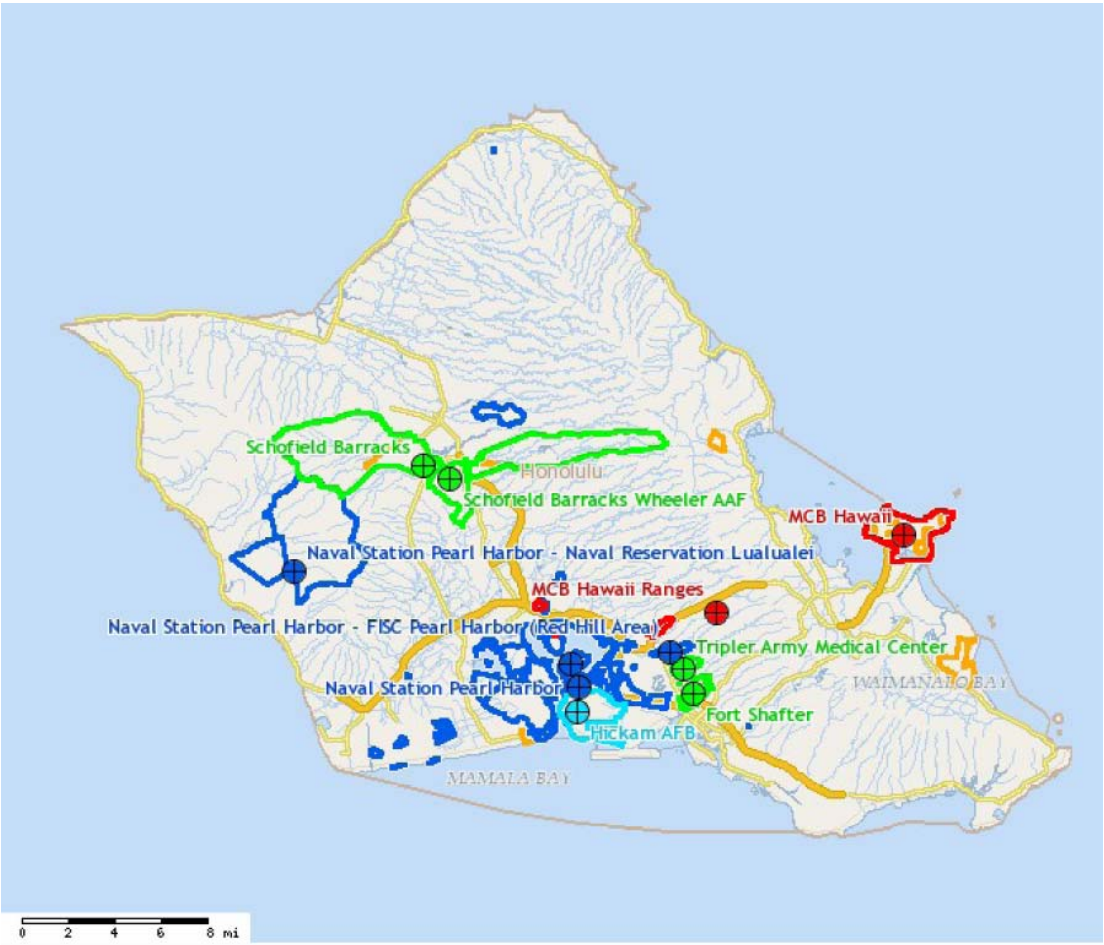
Appendix C: Regional Maps

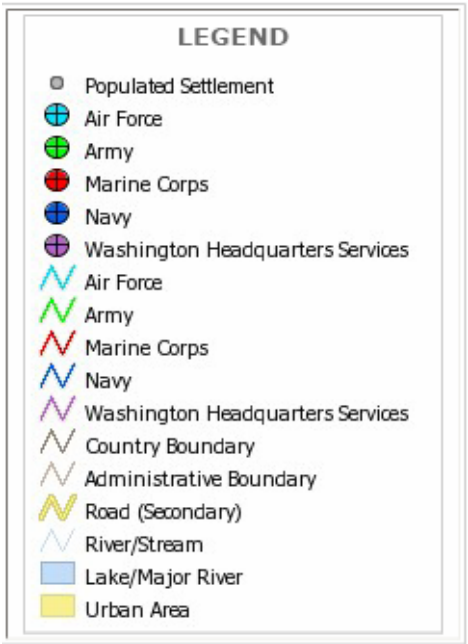
Hawaiian Islands



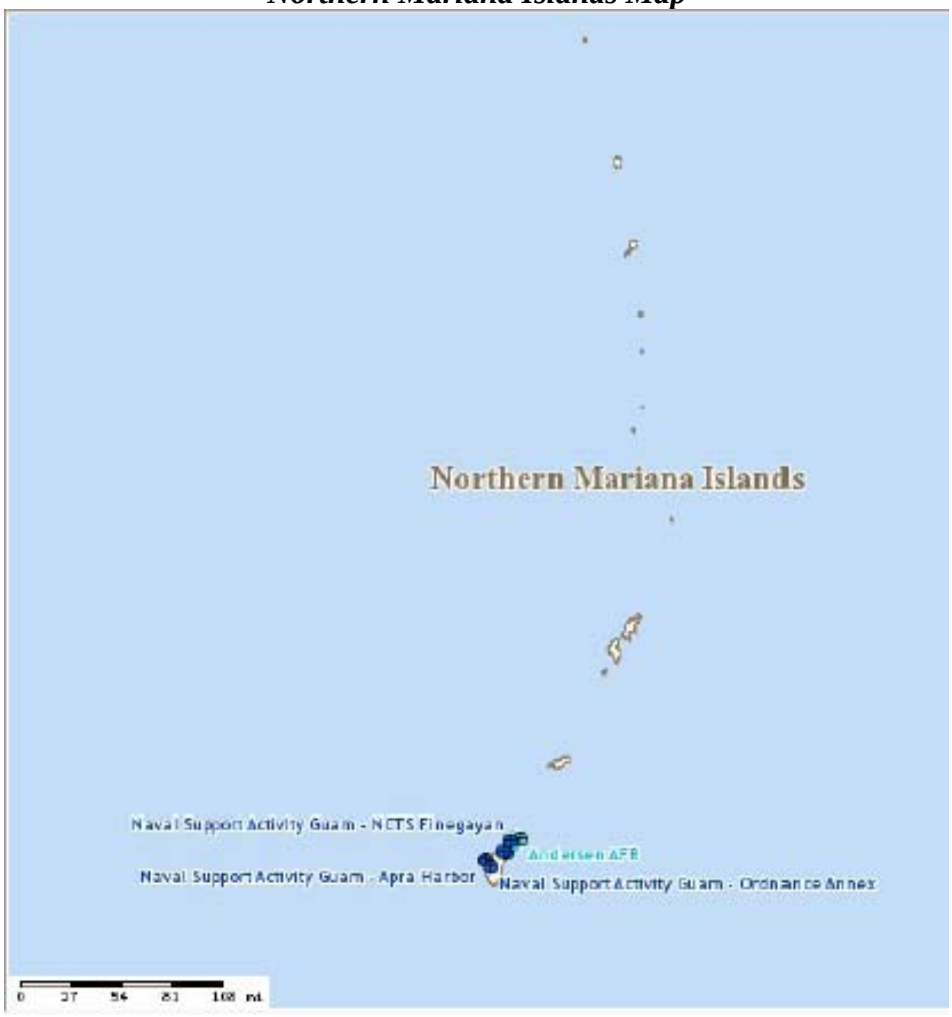


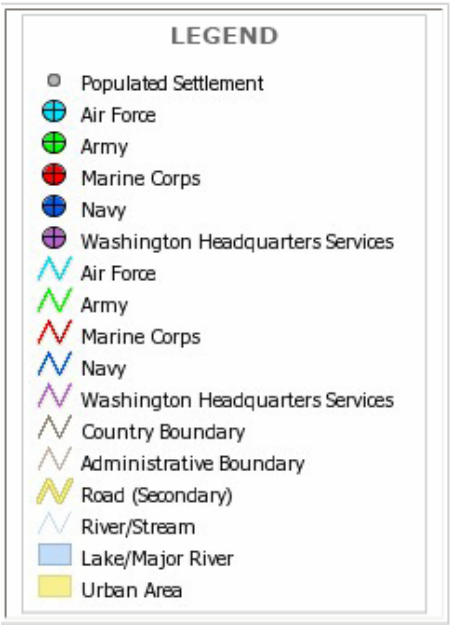
Oahu


Schofield Barracks
Honolulu
Schofield Barracks Wheeler AAF
MCB Hawaii
Naval Station Pearl Harbor - Naval Reservation Lualualei
MCB Hawaii Ranges
Naval Station Pearl Harbor - FISC Pearl Harbor (Red Hill Area)
Tripler Army Medical Center
WAIMANALO BAY
Naval Station Pearl Harbor
Fort Shafter
Hickam AFB
MAMALA BAY
0 2 4 6 8 mi


LEGEND
Populated Settlement
Air Force
Army
Marine Corps
Navy
Washington Headquarters Services
Air Force
Army
Marine Corps
Navy
Washington Headquarters Services
Country Boundary
Administrative Boundary
Road (Secondary)
River/Stream
Lake/Major River
Urban Area

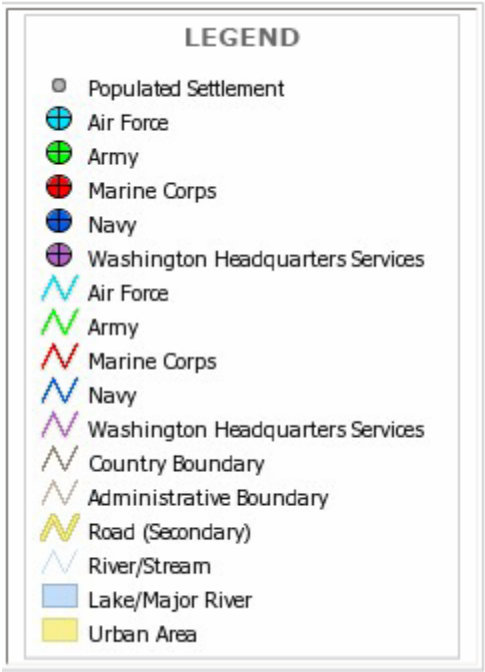
Northern Mariana Islands Map





Guam Map

Naval Support Activity Guam - NCTS Finegayan
UPI
ASATDA-31
Andersen AFB
Naval Support Activity Guam - NAS Agana CSO
AGANA
Naval Support Activity Guam - NCTS Barrigada
CAMP QUEZON
CAMP BRIGHT
Naval Support Activity Guam - Apra Harbor
AGAT
YIGO
Naval Support Activity Guam - Ordnance Annex
UMATAC
INARAJAN
0 1 2 3 4 NM


LEGEND
Populated Settlement
Air Force
Army
Marine Corps
Navy
Washington Headquarters Services
Air Force
Army
Marine Corps
Navy
Washington Headquarters Services
Country Boundary
Administrative Boundary
Road (Secondary)
River/Stream
Lake/Major River
Urban Area

Appendix D: Pre-Workshop Questionnaire

Participant Questionnaire

This questionnaire will be used to develop the agenda for the *Pacific Islands Regional Threatened, Endangered, and At Risk Species (TER-S) Workshop*. Please keep in mind that the workshop covers all the Hawaiian Archipelago (islands and atolls), as well as other Pacific region islands (e.g., Guam). Workshop results will address research, policy, and management issues relevant to TER-S, as well as TER-S interactions with non-native invasive species (NIS).

Research, Policy and Management Gaps and Needs: ***Given your areas of expertise, and using as much space as needed, please answer the following questions: "In my opinion,…***

1. *the key research questions regarding* ***proactive approaches*** *to preventing species endangerment and the potential for future listing are…*

2. *the key research and management questions regarding* ***multi-species or habitat/ecosystem*** *approaches to TER-S conservation are…*

3. *the key research and management questions regarding* ***TER-S and NIS interactions*** *are…*

4. *the top short-term* ***research*** *need is…*

5. *the top short-term* ***management or policy*** *need is…*

6. *the top long-term* ***research*** *need is…*

7. *the top long-term* ***management or policy*** *need is…*

Coordination Gaps and Needs: ***Based on your experience, please answer the following questions:***

1. *What are the highest priority* ***coordination*** *needs between the DoD and other federal, state, and local agencies and NGOs?* These can include data sharing, common data collection protocols, coordinated protection and management strategies, and so on. Please provide a brief explanation.

2. *What are the key* ***partnerships*** *that could be strengthened to improve coordination?* Please provide a brief explanation.

3. *What additional partnerships should DoD engage in to better conserve TER-S?* Please provide a brief explanation.

Future Land Management/Land Use Issues: ***Using your personal crystal ball, please provide your thoughts on the following:***

1. *What are the top future land use/land management changes adversely or positively affecting TER-S in the Pacific Islands?*

2. *What measures could be undertaken now or in the near future to prevent negative impacts to TER-S or the military training mission?*

Appendix E: Workshop Charge

Pacific Islands Region Threatened, Endangered, and At-Risk Species Workshop

6-8 June 2006 in Honolulu, Hawaii

Sponsors: This event is sponsored by the Strategic Environmental Research and Development Program (SERDP), Environmental Security Technology Certification Program (ESTCP), and Legacy Resource Management Program (Legacy). SERDP and ESTCP are Department of Defense (DoD) programs designed to support research, development, demonstration, and transition of environmental technologies required by the DoD to perform its mission. Legacy supports DoD efforts to protect, enhance, and conserve our nation's natural and cultural heritage through stewardship, leadership, and partnership while contributing to the long-term sustainability of DoD's land, air, and water resources for military use. All three programs seek to improve the DoD management of natural resources through investments in research, development, demonstration, or management initiatives.

Background: DoD's primary mission is training military service personnel and testing weaponry in support of national defense. It is also DoD's obligation and policy to protect our nation's natural and cultural resources. DoD serves as steward for approximately 29 million acres of land. These lands harbor more threatened, endangered, and at-risk species (TER-S) per acre than any other federal lands. DoD is committed to protecting its lands, oceans, and airspace, as well as the native ecosystems and species that inhabit them, and has established a range of policies to ensure proper stewardship while sustaining military mission readiness. Through improved understanding of native ecosystems, TER-S and their habitats, and their relationships to military training activities, DoD can work with stakeholders to enhance conservation of our nation's biological diversity.

More than 15 military installations and ranges are located throughout the Pacific Islands. The military controls over 200,000 acres (approximately 20%) of all land in the Hawaiian Island chain alone. Within these areas occur approximately 100 federally-listed threatened or endangered species—approximately 1/3 of the islands' listed species. Major threats to these species include loss and fragmentation of habitat, climate change, military training, and invasive species.

Objective: SERDP, ESTCP, and Legacy must determine how best to invest their limited research, demonstration, and management dollars to effectively address DoD's TER-S management requirements while maintaining the military training mission. To strategically guide future investments, and facilitate long-term cooperation and coordination among workshop participants, this workshop will:

1) identify and prioritize TER-S management needs among the Pacific Region Islands;
2) examine the current state of practice within DoD for TER-S management;
3) identify the gaps in knowledge, technology, and management that limit both the transition of emerging technologies and the implementation or development of new approaches; and
4) prioritize investment opportunities to address these gaps.

Approach: This workshop will take place 6-8 June 2006 at the Renaissance Ilikai in Honolulu, Hawaii. Participants will include senior researchers and managers from DoD, other federal and state agencies, academia, and the NGO community. The workshop will begin with an introductory session consisting of three plenary speakers—representing the State, NGO, and military communities—and two presentations on the state of terrestrial and aquatic TER-S in the region, including impacts to the continued viability of these species (e.g., invasive species, land-use changes). A field tour of Marine Corps Base Hawaii will highlight challenges faced by the military and provide examples of on-the-ground TER-S conservation projects. The following two days will comprise concurrent morning and afternoon breakout sessions on relevant topics that may include one or more presentations to help set the stage for discussion.

Appendix F: Questionnaire Response Matrix

Topic-Specific Needs	Research Needs	Management Needs	Coordination	Future Issues: Land Use/Management
Proactive Approaches ● Habitat requirements and minimum population sizes ● Prevent introductions and control invasive species ● Effects of climate change ● Meaningful coordination	**Short-Term** ● Census endemic species and monitor TER-S populations ● Prevent introductions of invasive species and develop effective control for top 2-4 (e.g., BTS, invasive ants, black twig borer, snails, slugs) ● Understand impacts of pathogens/disease in plants ● Characterize impact of management activities ● Education/communication	**Short-Term** ● Control worst NIS (rats, BTS, RIFA) ● Aerial dispersal of baits ● Increase populations of SAR ● Establish SAR mgt policy ● Minimum disruption of primary forests ● Implement INRMPs ● Risk-minimization as management policy ● Active coordination between researchers and end-users ● Overcome interagency collaboration funding constraints	**Needs** ● Earlier, better coordination with NPS, regulators, state ● Data collection standards/protocols to support sharing information ● Compatible GIS ● Management strategies ● Regional Species Recovery Councils (proactive aspect) ● Researcher access to Guam	**Adverse Changes** ● Loss of forest habitat and soil stabilizing ground cover ● Increasing development ● Increased military presence ● NIS invasions ● Habitat fragmentation
Multi-Species/Ecosystem ● Restoration of native habitat ● Maintain biodiversity ● Invasive species control ● Landscape approach ● Cooperative conservation	**Long-Term** ● Effects of rodenticides ● Biological control of NIS ● Tools to control NIS grasses ● Landscape control of BTS ● Prevent spread of NIS ● Habitat characterization ● Understand significance of short-term changes ● Stop declines in natives ● Climate change implications	**Long-Term** ● Prevent spread of NIS ● Strict control of NIS ● Enforcement/penalties ● Habitat restoration ● Establish buffers between live-fire areas and forests ● Improvements to ESA	**Key Partnerships** ● State DLNR ● USGS, USFWS, NOAA, USDA-WS ● Island-based ISCs and CGAPS ● Hawaii-Pacific CESU ● Managers ● Researchers	**Positive Changes** ● Return to native flora ● Control of NIS grasses to aid fire suppression ● Reverting farmland and grazing land to non-agriculture ● Increase public awareness ● Marine protected areas
Invasive Species ● Baseline inventory ● Thresholds for impacts ● Identify pathways ● Multi-species control ● TER-S interactions ● Designate 'protection areas'			**Additional Partnerships** ● NGOs ● Universities ● Local communities ● Private landowners ● Public awareness people	**Prevent Negative Impacts** ● Basic inventories for TER-S ● Habitat restoration ● Control wildland fire ● Effective NIS prevention plans ● Watershed-based approach ● Conservation law enforcement ● Results-oriented ESA

Appendix G: Session Charges

Workshop Objective: SERDP, ESTCP, and Legacy must determine how best to invest their limited research, demonstration, and management dollars to effectively address DoD's TER-S management requirements while maintaining the military training mission. To strategically guide future investments, and facilitate long-term cooperation and coordination among workshop participants, this workshop will:

1) identify TER-S management needs among the Pacific Region Islands;
2) examine the current state of practice within DoD for TER-S management;
3) identify the gaps in knowledge, technology, and management that limit both the transition of emerging technologies and the implementation or development of new approaches; and
4) prioritize investment opportunities to address these gaps.

Breakout Session I—Individual Species Approaches: Remaining Critical Questions
Given the current regulatory framework, many TER-S are managed at the individual species level. Although our goal is to manage TER-S at the ecosystem level, there are still many important unanswered questions that need to be addressed at the species level. In this session, we will divide groups into Aquatic TER-S (freshwater and marine), Plant TER-S, and Animal TER-S. The outcome objective is for participants to identify needs relevant to individual listed and at-risk species. Please use the following questions as a guideline to focus discussions:

- For what species and in what areas are basic inventories lacking?
- For what species is basic biological information and/or protocols to gather such information lacking, especially regarding those factors that influence persistence?
- How should population viability be defined for particular species?
- What populations of native species are declining, stable, increasing?
- How can scientists and managers proactively identify species at-risk of decline, as well as identify and quantify associated threat factors?
- How should species' levels of risk be prioritized?
- What would be optimal/ideal methods for effectively detecting native populations?
- What tools are available and/or needed to monitor species in remote/inaccessible locations?
- How can ecological requirements be determined when the distribution and habitat of many species have changed since the arrival of humans and spread of non-native species?
- What are the limiting factors preventing species recovery; how should those factors be ranked?
- What specific actions can be taken now and in the future to address factors limiting species recovery?

Breakout Session II—Ecosystem Management
By protecting habitat and the integrity of ecological systems upon which listed species depend (rather than focusing on the species itself), land managers can better ensure the long-term sustainability of these species while protecting other species that depend on the same ecological systems. In this session, we will divide groups into Dry Forest/Grassland, Wet Forest, and Coastal/Wetland/Riparian (limited to near-shore coastal issues). The outcome objective is for participants to identify needs relevant to multiple listed and at-risk species within an ecological system context. Please use the following questions as a guideline to focus discussions:

- What is our current understanding of the dynamics of rare or threatened insular ecosystems? What factors require further study?
- What are the most significant current and projected future threats to ecosystem integrity, and what management measures will reduce potential impacts?

- Specifically, are there ways to increase the compatibility of the DoD training/national defense mission with ecosystem conservation?
- What habitat parameters are required for sustaining populations of TER-S?
- What tools and approaches are needed to inventory, assess, and monitor habitat quantity and quality, and ecological system integrity?
- How can agencies manage at a system level to recover TER-S, while maintaining common species' population health and not adversely impacting the military mission? What indicators should be considered?
- At what point and by what methods should translocation be undertaken?
- What do we know about restoring endangered and sensitive ecosystems, and where do gaps exist? How can we better identify and understand those factors critical to successful restoration and/or maintenance of native ecosystems?
- What role do conservation areas play in studying ecosystems? How can managers improve their utility?
- How can scientists better predict management action impacts to populations or habitat? How can managers better assess impacts following implementation?

Breakout Session III— Impacts of Non-Native Invasive Species on TER-S
Due to their evolutionary history and high levels of endemism, native plants and animals in this region are particularly susceptible to the threats posed by the introduction and spread of non-native invasive species **(**NIS). In this session, groups will divide into Aquatic NIS (freshwater and marine), Plant NIS, and Animal NIS. The outcome objective is for participants to identify needs relevant to combating threats posed by NIS to TER-S throughout the region. Please use the following questions as a guideline to focus discussions:

- For what species and in what areas are baseline NIS inventories lacking?
- What are the immediate and long-term NIS threats to TER-S? What is the most effective way to measure these threats, and what actions can be taken to minimize their impacts to TER-S?
- What are the highest priority NIS in the region?
- What actions can be taken to prevent further NIS introductions, control expansions, and reduce populations at scales meaningful to species and community-level conservation? What groups/agencies/individuals should take each of these actions?
- Are there some thresholds for NIS percent cover that do not inhibit ecosystem integrity and TER-S survival that may be useful for management purposes?
- Are BMPs and protocols for prevention and control needed?
- What non-native diseases and pathogens are currently most problematic? Which do you anticipate being most problematic in the future?

Breakout Session IV—Synthesis and Prioritization of Needs
Synthesizing and prioritizing information resulting from breakout group discussions is a primary workshop objective. In this session, we will divide participants into Aquatic and Terrestrial breakout groups. Participants will synthesize and prioritize needs identified in earlier sessions, focusing on the highest priority needs and most critical issues relevant to TER-S and/or NIS research, demonstration, and management. The outcome objective is to provide a prioritized list of issues and/or actions that is as comprehensive as time permits. Please use the following matrix to capture outcomes:

Criteria for Prioritizing Research, Demonstration, and Management Needs

	Critical	High
Research	Research that potentially could have significant, long-term benefit.	Research that is important but not "ripe" (i.e., additional information is needed), or can wait until other more critical research is completed.
Demonstration	Field demonstrations or assessments that potentially could have significant, long-term benefit.	Field demonstrations that are important but not "ripe" (i.e., additional information is needed), or can wait until other more critical research is completed.
Management	Management actions that can significantly impact Pacific Islands Region TER-S.	Management actions that is important but not "ripe" (i.e., additional information is needed), or can wait until other more critical management is completed.

Breakout Session V—Technology Transfer

Leveraging information and working in partnership across organizations conserves resources and is critical to any successful conservation and restoration strategy over large geographic areas. In this session, we will divide groups into Information Sharing, Coordinated Management, and Partnerships. The outcome objective is for participants to identify collaborative opportunities at multiple spatial scales. Please use the following example questions as a guide to focus discussions:

Information Sharing

- How can inventory and monitoring programs be coordinated to expand the spatial scale of these activities?
- Are there accepted standards/protocols for data collection? If not, how can these best be developed?
- Do centralized databases on current and past insular ecological research and management exist? If so, what additions to their content may be useful?
- How can DoD get the word out about its TER-S management successes and needs?

Coordinated Management

- How can TER-S management and non-native invasive (NIS) species control be addressed jointly?
- To what extent are fire management, NIS control efforts, and ecosystem restoration coordinated across administrative boundaries? How can DoD enhance its coordination efforts?
- What opportunities exist for proactive conservation of species at risk?
- To what extent are watershed management strategies currently employed when considering conservation actions? Can and should this approach be expanded? If so, how?
- How can conservation values be infused into land-use planning? Is there a role for DoD in this effort? If so, what?
- How can conservation law enforcement efforts be coordinated among DoD and other agencies with conservation law enforcement responsibilities?

- What opportunities for coordinated management are identified through the State comprehensive plan, species recovery plans, installation Integrated Natural Resource Management Plans (INRMP), and so on?

Partnerships

- What opportunities exist for DoD to partner with the State, academia, NGOs, USGS, USFWS, USFS, USDA, NPS, NOAA, Hawaii Conservation Alliance, invasive species committees, the Hawaii-Pacific Islands Cooperative Ecosystem Studies Unit, engineers, practitioners, private landowners, and so on?
- How can coordination early in the planning process be facilitated?
- What mechanisms can be created to encourage public and private groups to pool limited resources to achieve a more cooperative, ecosystem-based regional approach to TER-S conservation?
- How can researchers more effectively communicate with resource managers and other end-users?
- How can DoD and other organizations foster public awareness and support for conservation work?

Appendix E: Workshop Agenda

Tuesday, June 6 - PLENARY SESSION AND FIELD TRIP				
Start	**End**	**Topic/Title**	**Speaker**	**Organization**
7:30 AM	11:30 AM	**Registration Open**	Veronica Rice	
7:45 AM	8:15 AM	**Continental breakfast**		
8:15 AM	8:30 AM	Conference Welcome and Charge	Dr. John Hall Mr. L. Peter Boice	SERDP/ESTCP DoD Conservation
8:30 AM	9:00 AM	State Welcome and Perspective	Mr. Peter Young	Hawaii DLNR
9:00 AM	9:30 AM	Research Community Perspective	Dr. William Brown	Bishop Museum
9:30 AM	9:45 AM	BREAK		
9:45 AM	10:30 AM	State of TER-S/NIS - Terrestrial	Dr. David Duffy	University of HI
10:30AM	11:15 AM	State of TER-S/NIS - Aquatic	Dr. Lu Eldredge	Bishop Museum
11:15 AM	11:45 AM	**Box lunches; board buses**		
11:45AM	4:45 PM	MCBH, Kaneohe field trip	Dr. Diane Drigot	MCB Hawaii
4:45 PM	6:00 PM	Board buses back to hotel		
6:30 PM	8:30 PM	**Evening Reception at Ilikai**	Mr. Alex Beehler	ODUSD(ES)
Wednesday, June 7 - BREAKOUT SESSIONS				
Start	**End**	**Topic/Title**	**Speaker/Chair**	**Organization**
7:30 AM	8:00 AM	**Continental breakfast**		
8:00 AM	8:30 AM	Overview of SERDP and ESTCP	Dr. John A. Hall	SERDP/ESTCP
8:30 AM	8:55 AM	Overview of Legacy Program	Mr. L. Peter Boice	Legacy
8:55 AM	9:00 AM	Proceed to breakouts		
		Session 1: Individual Species Approaches: Remaining Critical Questions		
9:00 AM	10:30 AM	1-1 Aquatic TER-S (Freshwater and Marine)	Dr. Dan Polhemus	Hawaii DLNR
9:00 AM	10:30 AM	1-2: Plant TER-S	Dr. Gene Jones	CSU Fullerton
9:00 AM	10:30 AM	1-3: Animal TER-S	Dr. Paul Banko	USGS
10:30AM	10:45 AM	**Break**		
		Breakout Session 1 cont.		
10:45 AM	12:00 PM	1-1 Aquatic TER-S (Freshwater and Marine)		
10:45 AM	12:00 PM	1-2: Plant TER-S		
10:45 AM	12:00 PM	1-3: Animal TER-S		
12:00 PM	12:30 PM	Morning sessions report		
12:30 PM	1:30 PM	**Lunch (on own)**		
1:30 PM	2:00 PM	Opening Speaker	Dr. Boone Kauffman	FS
2:00 PM	2:05 PM	Proceed to breakouts		
		Session 2: Ecosystem Management		
2:05 PM	3:30 PM	2-1 Dry Forest/Grassland	Dr. James Jacobi	USGS
2:05 PM	3:30 PM	2-2: Wet Forest	Dr. Flint Hughes	FS
2:05 PM	3:30 PM	2-3: Coastal/Wetlands/Riparian Areas	Mr. Barry Smith	U. of Guam
3:30 PM	3:45 PM	**Break**		

		Breakout session 2, cont.		
3:45 PM	5:00 PM	2-1 Dry Forest/Grassland		
3:45 PM	5:00 PM	2-2: Wet Forest		
3:45 PM	5:00 PM	2-3: Coastal/Wetlands/Riparian Areas		
5:00 PM	5:30 PM	Afternoon sessions report		
Thursday, June 8 - BREAKOUT SESSIONS				
Start	**End**	**Topic/Title**	**Speaker/Chair**	**Organization**
7:30 AM	8:15 AM	**Continental breakfast**		
8:15 AM	9:00 AM	Plenary Speaker	Major General R. Lee	Army National Guard
9:00 AM	9:30 AM	Opening Session speaker	Dr. Al Cofrancesco	COE/WES
9:30 AM	9:35 AM	Proceed to breakouts		
		Session 3: Impacts of NIS on TERS		
9:35 AM	10:30 AM	3-1 Aquatic Invasives (Freshwater, Marine)	Mr. Dave Gulko	Hawaii DLNR
9:35 AM	10:30 AM	3-2: Non-native Invasive Plants	Dr. Earl Campbell	FWS
9:35 AM	10:30 AM	3-3: Non-native Invasive Animals	Dr. Frank Howarth	Bishop Museum
		Breakout Session 3: cont.		
10:45 AM	12:30 PM	3-1 Aquatic Invasives (Freshwater, Marine)		
10:45 AM	12:30 PM	3-2: Non-native Invasive Plants		
10:45 AM	12:30 PM	3-3: Non-native Invasive Animals		
12:30 PM	1:00 PM	Morning sessions report		
1:00 PM	1:30 PM	**Lunch (onsite)**		
1:30 PM	1:40 PM	Opening Speaker	Dr. John Hall	SERDP/ESTCP
1:40 PM	1:45 PM	Proceed to breakouts		
		Session 4: Synthesis		
1:45 PM	3:15 PM	4-1 Synthesizing and Prioritizing Terrestrial Issues	Dr. John Hall Ms. Alicia Shepard	SERDP/ESTCP HGL
1:45 PM	3:15 PM	4-2 Synthesizing and Prioritizing Aquatic Issues	Mr. L. Peter Boice Dr. Leslie Orzetti	DoD Conservation HGL
3:15 PM	3:30 PM	Break		
		Session 5: Technology Transfer		
3:30 PM	3:45 PM	Opening Speaker	Dr. Mike Robotham	NRCS
3:45 PM	3:50 PM	Proceed to breakouts		
3:50 PM	5:15 PM	5-1 Information Sharing Among Federal, State, Local, and NGO Partners	Mr. Sky Harrison	USGS
3:50 PM	5:15 PM	5-2 Coordinating Management Activities	Mr. Lew Gorman	USFWS
3:50 PM	5:15 PM	5-3 Building Partnerships and Outreach Opportunities	Ms. Heidi Hirsh	USMC, HQ
5:15 PM	5:40 PM	Afternoon sessions report		