Department of Defense
Legacy Resource Management Program

Natural Selections

Volume 6, Issue 1 January 2010

Legacy Program Update

FY 2010 Legacy Program funding announcements to be made soon: We expect to begin making funding notifications for FY 2010 by late January.

Legacy Project Highlight of the Month

Legacy Project 08-410: Sea Level Rise Risk Assessment for DoD Coastal Installations

Coastal North Carolina is one of the United States' most vulnerable regions to climate change. More than 2,000 square miles of North Carolina's coastal ecosystems and urban areas are below one meter elevation and within the range of projected sea level rise from climate change by the year 2100. Recent studies demonstrated that, as climate change contributes to inundation, increased shoreline erosion and higher hurricane intensity, coastal DoD installations and low elevation island bases worldwide may experience significant losses in the absence of mitigation and local adaptation. The

The shoreline of Dare County, NC illustrates the conversion of coastal forests to open water. As sea level rises, forests are first replaced with shrub and marsh vegetation and then gradually transition to open water.

See Legacy, page 3

In The News

Safeguarding Wildlife from Climate Change: Quick Guide to Vulnerability Assessment

By Dr. Josh Lawler[1] and Dr. Bruce Stein[2]

[1] University of Washington
[2] National Wildlife Federation

Climate change is already disrupting the natural ecosystems on which both people and wildlife depend. The fate of our wildlife and wild places will depend on steps we take now to help them survive in the face of climate change. Vulnerability assessment is a tool for determining which species and ecosystems are likely to be the most severely affected by climate change. Understanding vulnerability to shifts in climate provides key insights for developing adaptation strategies designed to safeguard our natural heritage.

What is Vulnerability to Climate Change?

Plant and animal species—"wildlife" in the broadest

See Vulnerability Assessment, page 5

Inside This Issue

Naturally Speaking

From the Desk of L. Peter Boice,
DoD Deputy Director, Natural Resources and Director, Legacy Program

Responding to Climate Change

Climate change is arguably one of the most significant challenges we face today – and one that will be with us for generations to come. The evidence is overwhelming and inescapable – as I have seen recently in rolling power outages in Ecuador caused by diminished rainfall for hydroelectric generation, and in massive coral diebacks around St. John, US Virgin Islands (55% since the fall of 2005). We and the ecosystems on which we depend are being affected every day, in ways big and small, direct and indirect, obvious and subtle.

There should be little doubt that the need for immediate and far-ranging action is critical. Responding to the impacts of climate change will require substantial resources and wide-ranging commitments – investments in the future that may prove difficult to meet, but which are essential.

These introductory comments and the specific impacts described in this issue of Natural Selections will not be surprising to most of you. As natural resources professionals, you see evidence every day of climate change-related impacts. Some of you already are being asked to manage for these changes, or to help find suitable work-arounds. Others may have heard of our pending new policy statement on climate change –

> *"All DoD Components shall, to the extent practicable and utilizing the best science available, use existing vulnerability assessment tools to assess the potential impacts of global climate change to natural resources on DoD installations, identify significant natural resources that are likely to remain or become viable on DoD lands, and, when not in conflict with mission objectives, take steps to implement adaptive management to ensure the long-term sustainability of those resources. "*
> *(Review Draft of DoD Instruction 4715.3, Enclosure 3: 3)*

Yet, I expect some of you are asking, "This is all well and good, but what can I do?" I've had similar thoughts myself.

What we cannot do is nothing. The DoD Natural Resources Conservation Team is committed to providing specific information, tools and other resources to DoD natural resources professionals and others. This issue of Natural Selections describes some climate change-related projects that are underway or already completed. We will soon announce others.

Also, we're sponsoring a half-day training workshop, Climate Change Tools for Adapting Management Strategies, at the 2010 NMFWA annual meeting in Milwaukee. This workshop, scheduled for Monday, March 22, will provide information about tools that can be used to help adapt management strategies in light of climate change impacts. [Contact DoDNRConservation@bah.com for more information]. In addition to informing attendees of these various tools and how to use them, we will be soliciting input on other potential tools and studies that would be of value to DoD natural resources managers.

It seems clear that our changing climate will result in significant adverse impacts for decades to come – some severe, some irreversible. But what's also clear to me is that we all can – and must – do all we can to safeguard our resources as best we can, and to provide future generations with as much flexibility as we can. This is my commitment to my family, and to yours.

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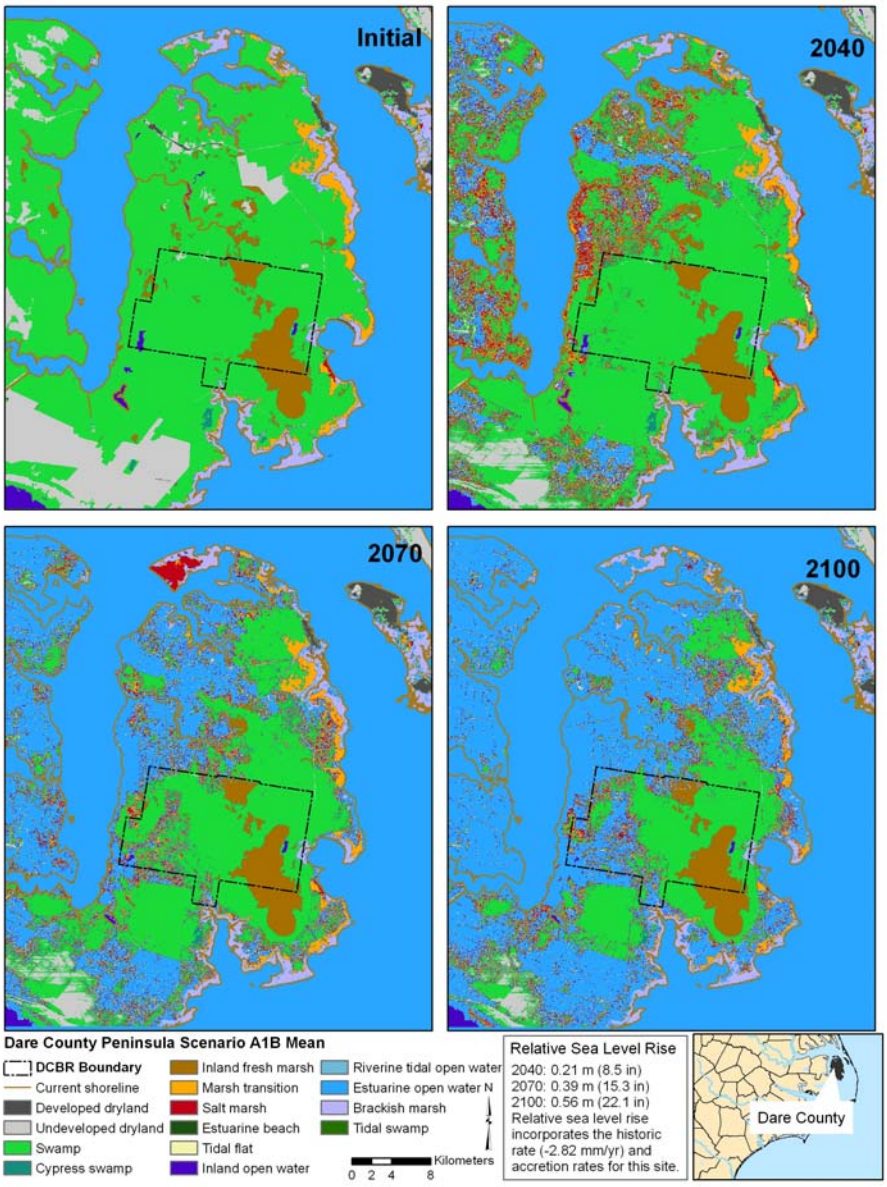
consequences of climate change and sea level rise are clear: the disruption of military operations, damage to base infrastructure, and threats to natural and cultural resources.

We conducted risk assessments of natural, cultural, and operational resources at risk in five coastal DoD installations in North Carolina (Air Force Dare County Bombing Range, Marine Corps Air Station and Naval Aviation Depot Cherry Point, Marine Corps Base Camp Lejeune, Army Military Ocean Terminal Sunny Point, and Navy Harvey Point).

We used available Light Detection and Ranging (LiDAR) digital elevation data for installations and geospatially referenced inventories of natural, cultural, and operational resources. Internationally recognized sea level rise scenarios from the most recent 2007 Intergovernmental Panel on Climate Change (IPCC) assessment were used to project best and worse case sea-level rise scenarios to 2100. Changes in vegetation land cover and open water in response to sea-level rise were modeled using the Sea Level Affecting Marshes Model (SLAMM) that simulates the dominant processes involved in wetland conversions and shoreline modifications during long-term sea level rise. Risk assessments of natural, cultural, and operational resources on DoD's North Carolina installations were projected at ten-year intervals to 2100. GIS map products and inventories of resources at risk were produced for each installation. Potential mitigation strategies were discussed for each installation.



Land cover change for a moderate sea level rise projection at one NC coastal installation illustrates the dramatic conversion of land to open water for the Dare County, NC peninsula. Under the moderate IPCC sea level rise scenario, all Air Force and Navy testing and training operations will be halted by 2100 and major interruptions will begin by 2050 as forest land converts to wetter marsh transition vegetation.

A summary of sea level rise projections for North Carolina coastal installations indicates that DoD installations will have varying degrees of risk based on actual sea level rise from the present to 2100. The two installations facing the greatest risks from sea level rise are Dare County Bombing Range and Cherry Point Piney Island. SLAMM simulations indicate that a moderate sea level rise of approximately 0.7 m will flood large portions of these installations. A close look at the impacts of sea level rise on one installation in coastal North Carolina, Dare County Bombing Range, predicts that sea level rise will radically alter the land cover on the Dare County Peninsula and on the bombing range.

Installations facing moderate risk include Harvey Point, Cherry Point OLF Atlantic, and MCB Camp Lejeune. Impacts from simulations of sea level rise indicate that some base operations could be hindered due to flooding or saturation of infrastructure. Generally these impacts are limited in their spatial extent on the installation. Facilities with predicted minor impacts from sea level rise include the main installation at Cherry Point and Sunny Point. Simulation results demonstrate that forested wetlands readily convert to wetter wetland types such as salt marsh, marsh transition, and brackish marsh. These marshes, in turn, transition to tidal flats and then open water 50 to 90 years into the model simulations. Even a moderate acceleration in the rates of sea level rise floods large parts of the peninsula by mid-century.

Impacts from sea level rise could eliminate installation functionality due to poor access and the flooding of base infrastructure. Other impacts would include degradation of habitat for rare species such as the American alligator and the red-cockaded woodpecker. Migratory birds and water fowl use this area as a corridor and wintering grounds; the flooding of the forested wetland and marshes will limit the habitat they can use in this part of North Carolina.

Changing environmental conditions may have an impact on accretion values, the rate at which new soil is formed from sediment capture and vegetation litter. The level of salinity is an environmental condition affecting accretion rates in the Dare County peninsula. In general, as salinity levels increase, accretion rates decrease. Inundation of salt marshes may increase accretion rates due to increased nutrient supplies. Alternatively, saltwater intrusion may accelerate decomposition thus decreasing vertical accretion.

A sea level rise mitigation strategy to remedy the impacts from saline water could include managing coastal ecosystem to maximize sediment accretion and raise ground elevation to exceed sea level rise, the reestablishment of oyster reefs and coastal marshes, and the installation of tide gates. Oyster reefs could reduce shoreline erosion and increase the rate of reestablishment of marshes. Tide gates act as one-way valves: allowing fresh water from the peninsula to flow into the estuary, but preventing saline estuary water from entering the canals. The goal of this project is to quantify the risk of sea level rise on the ability of the services to execute their mission in support of national security and the stewardship of the nation's natural and cultural resources.

Adapted from a fact sheet prepared by Robert Mickler, Alion Science and Technology, rmickler@alionscience.com

DoD TES Document Repository

Imagine a free, single source for scientifically relevant, but otherwise unavailable, information on threatened and endangered species (TES)...

Welcome to the Department of Defense's (DoD) TES Document Repository (http://dodtes.nbii.gov). The Repository houses scientifically valid studies, reports, and other documents about high priority species on DoD lands that are NOT already published in peer reviewed literature. That is, gray literature. Using the information in these documents can inform management actions, help with partnering efforts, and facilitate the Section 7 consultation process under Endangered Species Act requirements. BUT… the system is only as good as YOU make it.

Please help out: Send in new documents! If you have a university research study, an NGO inventory, or any other technical document relating to the management or monitoring of TES, please submit it for publication in the Repository by sending an e-mail to: TESRepository@hgl.com.

Call for NEPA Examples

Have you ever used NEPA for your bird-related projects? Or have you had any problems or questions about NEPA and your bird projects? If so, we would like to use your examples to create a step-by-step guidance document about how to properly execute NEPA when dealing with migratory birds. Please send your examples to Chris Eberly (ceberly@dodpif.org) no later than February 1, 2010.

Vulnerability Assessment, continued from page 1

sense—vary widely in how they are likely to respond to changes in temperature, precipitation, and other factors brought about by climate change. Vulnerability to climate change refers to the likelihood that these climate-induced shifts will have an adverse impact on a given species, habitat, or ecosystem. More vulnerable species and systems are likely to experience greater impacts from climate change, while less vulnerable species and systems will be less affected, or may even benefit.

Many coastal habitats are vulnerable to sea-level rise and other climate change effects. Photo by Tom Nebel, USFWS.

A Key Tool for Adaptation Planning

With the impact of climate change on our wildlife and natural ecosystems becoming increasingly evident, wildlife and natural resource managers are now confronting the difficult task of re-envisioning conservation for a changing world. Preparing for and responding to the impacts of climate change—climate change adaptation—is fast becoming an overarching framework for conservation and wildlife management. Adaptation planning, in turn, depends on a sound understanding of how our changing climate is likely to affect wildlife and their habitats—critical information provided by vulnerability assessments. Vulnerability assessments are a key tool for federal and state resource managers in the development of effective climate change adaptation strategies. By detailing the ecological impacts and implications of climate change on our wildlife, vulnerability assessments can help managers:

- identify those species and systems most likely to be in need of conservation actions as a result of climate change;
- develop adaptation strategies tailored for managing species and habitats in greatest need;
- foster collaboration at statewide and regional scales by providing a shared understanding of impacts and management options; and
- allow scarce resources for wildlife conservation to be allocated efficiently in the face of climate change.

Components of Vulnerability

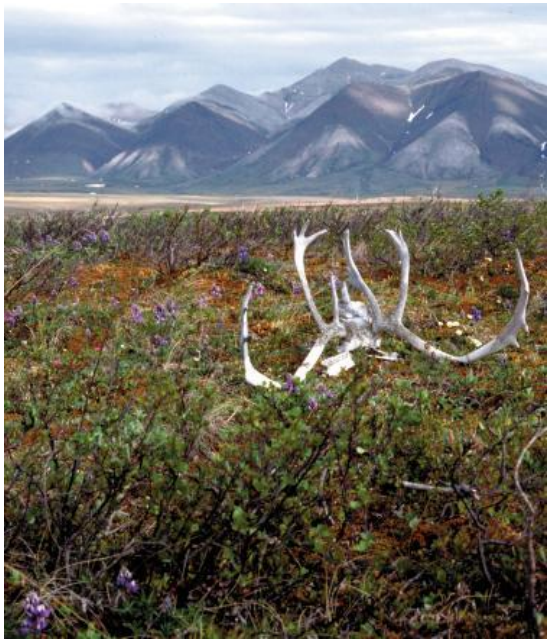
Vulnerability consists of two basic elements; sensitivity and exposure. Sensitivity is a measure of whether and how a species or system is likely to be affected by a given change in climate. Exposure is a measure of how much of a change in climate a species is likely to experience.

As an example, fair-skinned individuals usually are more sensitive to sunburn than those with deeper skin tones. However, depending on one's exposure to UV rays (e.g., hours in the sun or strength of the sun's rays), most anyone can suffer a sunburn. Vulnerability—in this case to sunburn—is a function of both sensitivity and exposure. Assessing vulnerability thus entails analyzing both the inherent sensitivity of a species or system to likely climate change effects, as well as the likely magnitude or degree of exposure to those effects.

Assessing Sensitivity

The sensitivity of a species, habitat, or ecosystem to climate change reflects the degree to which that organism or system is susceptible, either directly or indirectly, to those changes. For example, a cold-water trout species living at the upper end of its temperature threshold would be highly sensitive to increases in water temperature.

Fish that thrive in cold water, such as trout and salmon, are particularly sensitive to increases in water temperature. Photo: brook trout, by Eric Engbretson, USFWS.



The arctic is experiencing extremely rapid warming, exposing many of its species and habitats to unprecedented levels of change. Photo: USFWS.

Many aspects of a species' life history make it more or less sensitive to climate change. For example, is the species:

- physiologically sensitive to changes in temperature or precipitation?
- found in habitats likely to be significantly affected by climate change?
- closely tied to one or more disturbance regimes (e.g., fire, floods) likely to be altered by climate change?
- limited in its ability to disperse?
- highly dependent on specialized habitats, on certain other species, or on the timing of ecological events?

There are several approaches to answering these and other pertinent questions regarding sensitivity. The answers can be derived from a variety of sources including literature searches, expert opinion, and models. Various types of models can be used including population models, energetics models, correlative "climate envelope" models, and dispersal models.

Assessing Exposure

Exposure refers to the amount of climatic or environmental change that a species, habitat, or ecosystem is facing. Assessing exposure entails projecting future climatic conditions, preferably with a focus on those with ecologically relevant effects (e.g., extremes in summer temperature or onset of ice-break-up). Types of information useful for assessing the potential exposure of a species or a system to climate change include:

Climate Change Projections – Assessments can take advantage of summarized regional trends (e.g., average temperatures projected across a region) or more geographically explicit data from downscaled-climate projections derived from general circulation models (GCMs) or regional climate models (RCMs).

Historic Climate Trends – As with the stock market, although past performance is no guarantee of future results, past climate trends offer useful predictors of future change. Historic climatic trends are often available for a region as weather-station data or modeled grids of temperature and/or precipitation.

Projected Habitat Changes – Many models can be used to simulate habitat changes in response to altered climates, such as dynamic global vegetation models, forest gap models, correlative "climate envelope" models, hydrologic models, sea level rise projections, and fire models.

Expert Opinion – In many cases, downscaled climate data and vegetation-model projections will be unavailable or too expensive to develop. In these instances, expert opinions can be useful for assessing the likelihood of how future local climates will reflect regional projections or how habitats will change. Expert opinions should be accompanied by an estimate of certainty and description of the assumptions, evidence, or reasoning underlying the opinion.

Ten Tips for Climate Change Vulnerability Assessments

There is no single best approach to assessing wildlife vulnerability to climate change. Assessments can focus on plant and animal species, habitats, or ecosystems, depending on the specific needs of the wildlife or resource managers. Assessments can be quantitative, qualitative, or both. They can vary considerably in their level of detail,

scale, and scope, depending on factors such as data availability, levels of funding, and time constraints, as well as the particular conservation goal or goals of concern. And they can consider one or more scenarios of future change. Indeed, there is no "one-size-fits-all" method for conducting vulnerability assessments; the approach taken will depend on user needs and other considerations.

Based on a review of many of the existing assessments of wildlife vulnerability to climate change that have been carried out or are underway, the National Wildlife Federation has identified the following ten tips for conducting wildlife and ecosystem vulnerability assessments.

Assessing the vulnerability of species, such as the American pika, involves consideration of their sensitivity to changes in climate, and the likely degree of exposure to those changes. Photo courtesy Alan D. Wilson, www.naturespicsonline.com.

1. Begin with a clear understanding of user needs. Why is the assessment needed (e.g., update of an installation's INRMP, national wildlife refuge or national forest planning), and how will it be used?

2. Determine the target of the assessment. Will the assessment address species, ecosystems, habitats, specific sites (e.g., wildlife refuges, state parks), or some combination of these targets?

3. Determine the spatial and/or temporal scale of the assessment. What will the geographic extent of the assessment be? What is the ideal spatial and temporal resolution for climate, vegetation, ecosystem, or species data? What is the level of specificity or precision required in the results?

4. Design assessment products with stakeholder input. What types of products will be most useful to intended users? Will maps, lists, rankings, tables, or some combination of products be most useful?

5. Collaborate with regional experts. Who in the region (or nationally) has expertise in climate change, vegetation, hydrological, fire, or sea-level modeling, and knowledge of the species, habitats, or ecosystems? Can they provide data or advice on obtaining appropriate data?

6. Build from existing efforts. Use other assessments as models and sources of relevant information. Descriptions of several such efforts are available online through a wildlife and climate change webinar series hosted by NWF and US Fish and Wildlife Service.

7. Weigh budget and time constraints when selecting tools and methods. Carefully consider the level of specificity needed when selecting tools and methods. Some modeling approaches take considerable time, funding, and expertise to run and apply.

8. Understand, describe, and if possible quantify the uncertainties in the results. Where are the key uncertainties in the results? Are there particular results relatively robust to uncertainties in, for example, precipitation projections?

9. Design the assessment so it can be easily repeated. Ideally, updated climate and climate-impact projections can be applied to an existing assessment framework and new results easily generated.

10. Share the information about your process and results. Sharing information and results can help eliminate duplication of efforts and can foster collaboration across states and institutions.

This Quick Guide to Vulnerability Assessment is an interim product of a vulnerability assessment working group convened by the National Wildlife Federation in cooperation with the U.S. Fish and Wildlife Service and with the financial support of the DoD Legacy Resource Management Program (09-460).

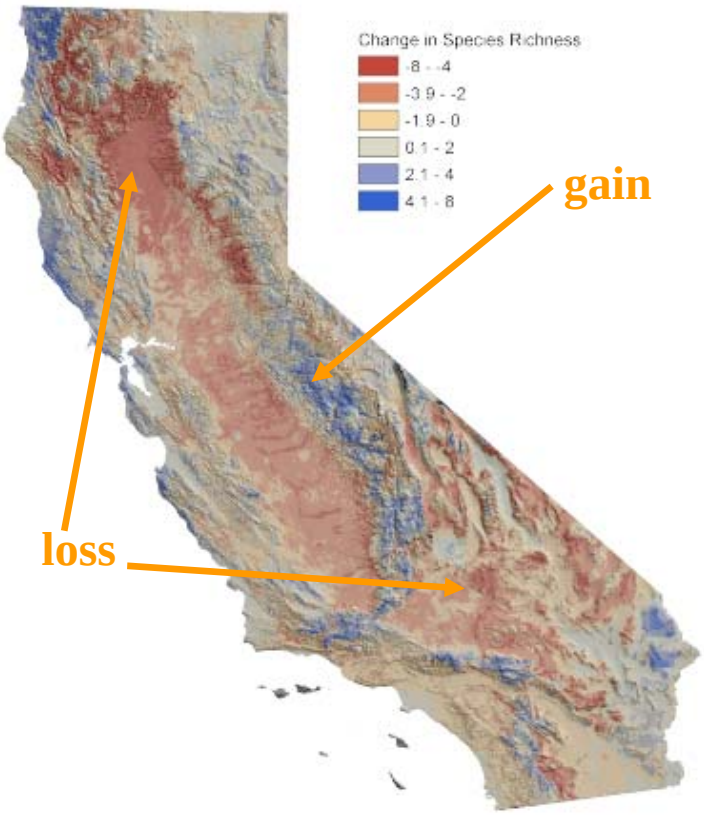
Climate Change, Birds, and Bases in California

By John Wiens
PRBO Conservation Science, Petaluma, CA

Department of Defense lands are hotbeds of biological diversity. Natural resource management has been enormously successful at maintaining the environmental health of military installations and, correspondingly, the persistence of many plant and animal species and the capacity of the installations to sustain their testing and training functions. But climate change presents new threats, threats that know no boundaries and that transcend our past experience. Effective stewardship of natural resources will require an understanding of what the future is likely to bring.

Short of reading tea leaves or astrological signs, models are the only way to gain a glimpse into what the future may look like. Assessments of future climate change are derived from global circulation models, and other models that integrate climate change with oceanography, hydrology, and bathymetry project sea-level rise and its consequences. Species-distribution or "bioclimatic envelope" models are being used to predict how the distributions of plant and animal species may shift under future climates. This latter approach uses the climatic and environmental conditions of where a species currently occurs to create a model of current distribution, which is then coupled with projections of future climate and environment to predict where the species is likely to occur under different scenarios of future conditions.

At PRBO Conservation Science (formerly Point Reyes Bird Observatory; see http://www.prbo.org), we have used this approach to assess how climate change is likely to affect the distributions of breeding land-birds in California. The focus on California is appropriate because the region is a center of biodiversity within the United States (and because it is where PRBO is based). Birds are appropriate targets for this analysis because their distributions are well known, they are useful indicators of environmental change, and they are a focus of environmental management on many DoD installations. For 60 bird species designated by California Partners In Flight as representative of five major habitat types within the state, we matched occurrence records from 16,742 point-count locations with climate variables and general vegetation categories to model current distributions at an 800-m scale of resolution. We then used downscaled projections of future climate conditions based on two climate-change models (NCAR CCSM3.0 and GDFL CM2.1) to project future bird species distributions using two distribution-modeling algorithms (Maxent and Generalized Additive Models) (see http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0006825 for details). Future climate conditions were based on a medium-high emissions scenario averaged across the years 2040-2070.

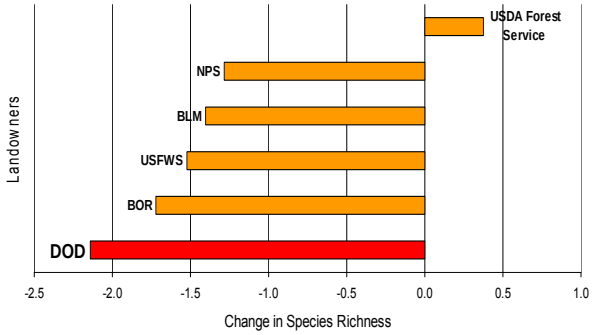


The number of bird species in an area will change with climate change. Red colors indicate the greatest decreases, blue the greatest increases.

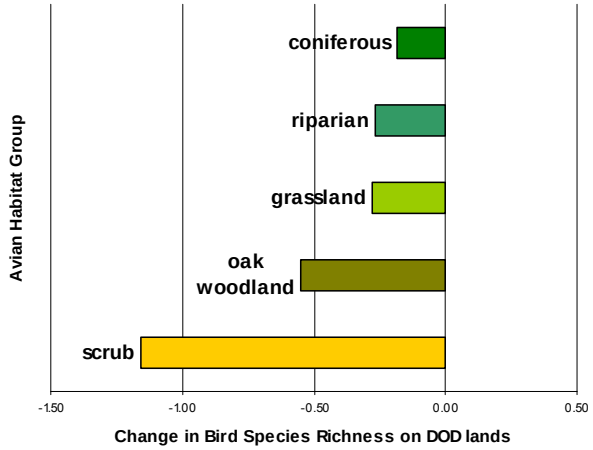
Our modeling results suggest that there may be dramatic changes in store for bird distributions in California. Some species, such as Ash-throated Flycatchers and Blue-gray Gnatcatchers, are likely to expand their distributions, whereas others, such as Varied Thrushes and White-crowned Sparrows, may disappear from much of their current range within the state. Overall, some 75% of the 60 species are projected to decrease in their distributional occurrence.

These changes will not be evenly spread across the state, however. There are likely to be "hotspots" of gains or losses in species richness (the number of bird species occurring in an area) in certain parts of California, particularly in the southern Sierra Nevada mountains (gains) and parts of the Central Valley and Mohave Desert (losses).

To assess how these shifts may relate to DoD, we partitioned our model analyses by categories of land ownership or management. Roughly half of California is in public ownership. DoD administers 8% of these lands, with many bases located in desert and coastal areas of southern California. When we compare the projected changes in species with a land-ownership map of the state, only lands administered by the U.S. Forest Service are expected to gain species, largely because much of this land is located at higher elevations in mountains to which many species are expected to shift. The remaining public-land entities are all expected to lose species, but DoD lands are projected to experience the greatest losses in species richness.



DoD lands show the largest predicted decrease in bird species among six Federal agencies in California.

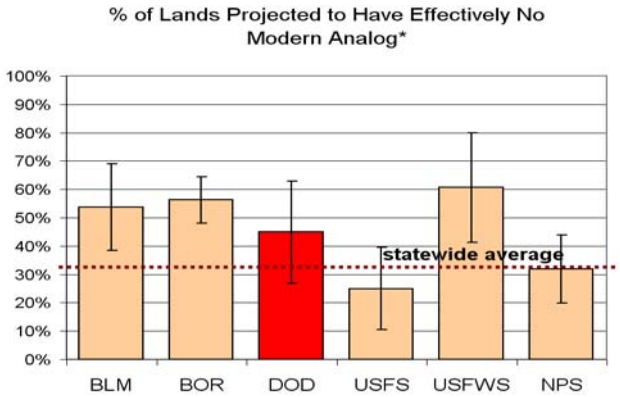


All major habitat types on DoD lands in California are predicted to suffer losses in bird species, with the greatest reductions occurring in scrub-chaparral habitats.

To see what kinds of birds are predicted to change distributions, we grouped species by their habitat associations. For DoD lands, all of the habitat groupings are projected to lose species, with the greatest losses occurring among species associated with scrub-chaparral habitats.

Even within this grouping, however, different species are anticipated to shift in different ways. Cactus Wrens, for example, are projected to shift out of much of their current range, whereas Rufous-crowned Sparrows may expand their distribution northward along the coastal mountains and foothills of the Sierra Nevada in central and northern California.

These independent shifts among species in response to climate and vegetation changes may produce some unanticipated results. The assemblage of species that currently occur together in a local area may be "re-shuffled" as some species shift away from the area and other, new species enter the area from elsewhere. This re-shuffling may produce new and novel combinations of species, "no-analog" assemblages that contain species that do not currently occur together anywhere in California. Averaging across models, some 33% of the state is projected to contain such no-analog assemblages by 2070. The occurrence of no-analog assemblages is likely to be greater on lands administered by several federal agencies, including DoD.



The proportion of areas containing "no-analog" bird assemblages in the future – combinations of species that have no contemporary counterpart in California – are projected to be greater on lands administered by several Federal agencies (including DoD) than for the state as a whole.

This result is more than just interesting. It suggests that the species that will occur together in such assemblages will be confronted with new suites of competitors, predators, and parasites. And what we project for birds is likely to hold as well for a host of other plants and animals. The cascading effects of these new and novel species interactions are likely to produce surprises, further challenging resource managers.

What do these model projections imply for the management of natural resources on military lands in California? Our models, like most current species-distribution modeling, leave out some important factors. Differences in dispersal capabilities among species are not considered, nor are the effects of interactions among species. The analyses stop at the California state line, but the birds (and the effects of climate change) do not, so the potential effects of movements into or out of the state are not considered. These are all priorities for future modeling efforts. Even with these caveats and uncertainties, however, there are some clear messages. It seems likely that the effects of climate change on birds may be especially great on DoD lands in California.

This is not because these lands are poor habitats or are badly managed; in fact, quite the opposite is true. Rather, it is because of where DoD lands in California are located, the ways in which climate change is likely to affect these areas, and the vulnerability to the impending climate changes of the bird species that currently occur there. There is also little reason to believe that these results are peculiar to the 60 species we analyzed, or only to birds. Some of the changes in bird distributions are due to projected changes in vegetation, and these changes are likely to affect other wildlife species and communities. More importantly, environmental management on DoD lands and the suitability and sustainability of these lands to support the military mission may be compromised by the direct and indirect effects of climate change. In order to repeat the successes of the past, natural resource management will need to adapt to the oncoming changes. The birds may be telling us something.

Amphibians and Climate Change

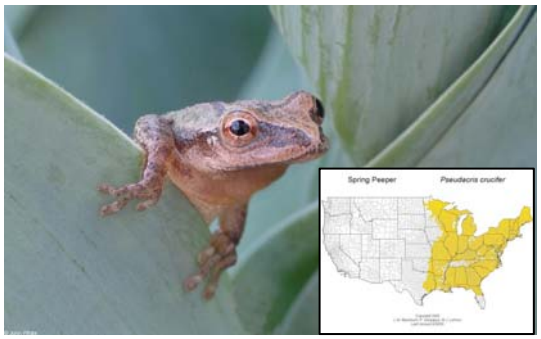
By V. T. Vredenburg, M. McDonald, & T. Sayre
Department of Biology
San Francisco State University

It is no secret that the earth's biodiversity is increasingly threatened by human activity. Until recently, biodiversity conservation focused on preserving habitat. The idea was simple: conserve the land and that will in turn save the organisms living within the protected habitat. This type of thinking has been turned upside down recently by undeniably strong evidence showing the destructive force of human pressure on our entire biosphere. Clearly, conserving habitat is incredibly important (and military instillations represent some of the best protected habitat in the USA), but it cannot be our only strategy to save species from human-mediated extinction. Some have called amphibians (frogs, toads, salamanders and the less-well known caecilians) our modern day bellwether for the global biodiversity crisis currently underway. Many people may not know that we are currently entering a mass extinction event, but most are familiar with the last great mass extinction event because of the charismatic group of species that left behind massive fossilized teeth and bones. Just ask any child what their favorite animal is and most will exclaim, "Dinosaurs!" Amphibians are suffering terrible losses today, but they are long-term survivors. Unlike dinosaurs, amphibians made it through the last mass worldwide extinction event pretty much unscathed. In fact, they made it through the last 4 mass extinction events while millions of other species did not. The world's amphibians (>6500 species), the first great vertebrate line to colonize land, are at greater risk of extinction today than they have been for the last 300 million years. Many scientists believe that climate change (caused by human activity) is involved.

The world took notice when many accounts of declining amphibians from relatively pristine areas, such as designated wilderness areas and national parks, began to surface in the late 1980s and early 1990s (please visit http://amphibiaweb.org/ for details). In these areas, global climate change may be directly and/or indirectly responsible for declines. Extinctions and extirpations of Mountain Yellow-Legged Frogs in California, and Harlequin Frogs and Golden Toads in highland Costa Rica are the subject of inquiry into climate-linked declines. For example, one study suggests that global climate change has made conditions more favorable for a new fungal disease (chytridiomycosis) thus indirectly leading to extinctions and declines of amphibians. Direct consequences of climate change can also be expected because amphibians may be more sensitive to climate change than other species. Because of their permeable skin, biphasic lifecycles (tadpoles develop in water and adults live on land) and unshelled eggs, amphibians may be extremely sensitive to small changes in temperature and moisture. Here we summarize some of the evidence that climate change has directly and indirect affected amphibian populations around the world.

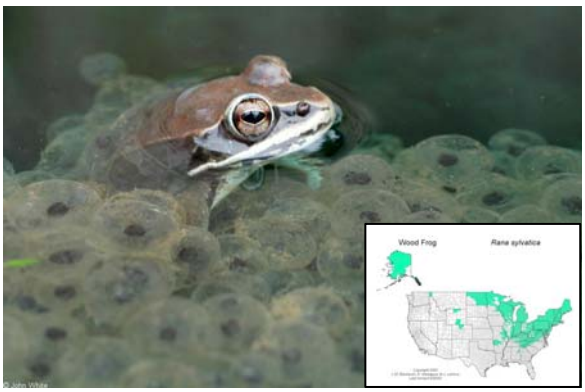
Climate Change and Amphibian Breeding Phenology

The timing of amphibian breeding (phenology) is largely driven by environmental cues such as temperature and moisture; because of this, their breeding phenology may be directly affected by climate change. Amphibians in temperate regions may be even more susceptible to increases in temperatures because they typically have shorter growing seasons than in tropical areas with more constant weather. Most temperate species spend a large portion of the year inactive, escaping either cold winters or hot summers by burrowing underground or staying underwater. Subtle increases in temperature or moisture trigger them to emerge from their hibernacula, or winter hiding spots. Immediately upon immergence, they migrate to ponds or streams to breed. Thus, one hypothesized direct effect of climate change on amphibians is a trend towards early breeding as average temperatures increase. If amphibians breed too early in the season, they may be more vulnerable to early snowmelt-induced floods and early season freezes that are usually less common later in the season. For example, frogs that breed in rivers may be more susceptible to losing their eggs to flood events if they breed too early in the season. To test this hypothesis, researchers from Europe and North America have analyzed long-term data sets looking for trends towards earlier breeding. Some amphibians do show a trend towards earlier breeding.



The Northern Spring Peeper (*Pseudacris crucifer*) is affected by climate change in the northern part of its distribution, but not in the southern part. Photo © 2007 John White; map from Laura Blackburn, Priya Nanjappa, and Michael J. Lannoo (2001) US Amphibian Dist. Maps (http://amphibiaweb.org/).

The trend may vary regionally for a single species. For example, the spring peeper (*Pseudacris crucifer*) is breeding earlier in Ithaca, New York in the 1990s than it did in 1900s but does not appear to be breeding earlier in Michigan. Other species that records show are breeding earlier in North America are the American Bullfrog (*Rana catesbeiana*), and the Wood Frog (*Rana sylvatica*). There is no evidence so far that the American Toad (*Bufo americanus*), Western Toad (*Bufo boreas*), Cascades Frog (*Rana cascadae*) or the Green Frog (*Rana clamitans*) are breeding earlier, but more data are needed both on these species and on others throughout the United States.



The Wood Frog (*Rana sylvatica*), is breeding earlier each year due to climate change. Photo © 2007 John White; map from Laura Blackburn, Priya Nanjappa, and Michael J. Lannoo (2001) US Amphibian Dist. Maps (http://amphibiaweb.org/).

Other Direct Effects of Climate Change on Amphibians

To date, there is limited data available to fully determine the scope of climate change on amphibians because most datasets are not long enough for analyses incorporating changes in climate. Hopefully, now that monitoring programs are in place all over the world, we will have more data to better answer questions associated with amphibian declines and climate change in the future. In the USA, monitoring of amphibians on lands protected by military installations is a major source of new amphibian population data (USGS and USFWS). However, even with large data sets, it can be difficult to determine causal relationships, because other environmental factors vary concurrently.

A handful of studies, mostly from the tropics, have analyzed available data, and have found casual relationships between

declines and irregular climate conditions. In Brazil between 1979 and 1982, Heyer et al. (1988) found that severe frosts correspond to the extinction of five frog species. Also in Brazil, Weygoldt (1989) found that other declines were associated with dry winters. In eastern Australia, Ingram (1990) and Laurance (1996), both found a correlation between drought and massive declines of stream-dwelling rain forest amphibians. In North America, Corn and Fogleman (1984), found a correlation between the extinction of montane populations of the Northern Leopard Frog (*Rana pipiens*) and drought. In Puerto Rico, Stewart (1995) found that the dramatic population declines in 1983 of the Puerto Rican coqui, *Eleutherodactylus coqui*, and other Puerto Rican frog species corresponded to an increased number of extended dry periods (i.e. multiple consecutive days with less than 3mm of rainfall). In other words, in Puerto Rico, the length of dry periods had noticeably increased and it was not as simple as an overall decrease in the annual precipitation. Finally, in the cloud forests of Monteverde, Costa Rica, Pounds et al. (1999 and 1994) found a correlation between the pattern of dry mist frequency associated with highland forests and the decline and likely extinction of several species of amphibians, including the popular Golden Toad, *Bufo periglenes*, the poster child for amphibian declines. More recently Pounds et al. (2006) report amphibian declines following regional warming periods.

Summary

The causes of amphibian declines in protected areas are often enigmatic (Stuart 2004), and climate change inherently affects environments in a broad manner. Thus, it is often difficult to understand whether climate change has a direct effect on the decline and or extinction of any given species. However, some broad studies (Parmesan 2003) have shown a globally consistent trend using data from many amphibian species. A probabilistic model showed a correlation between climate change on biotic markers such as phenological shifts and population distributions. Spatial and temporal sign changes showed that most (84%) of the species surveyed had a biotic response to warming, leading to the conclusion that climate change is indeed a factor affecting amphibians in our biosphere.

Strategic Environmental Research and Development Program Activities Related to Climate Change

By John Thigpen[1] and John A. Hall[2]
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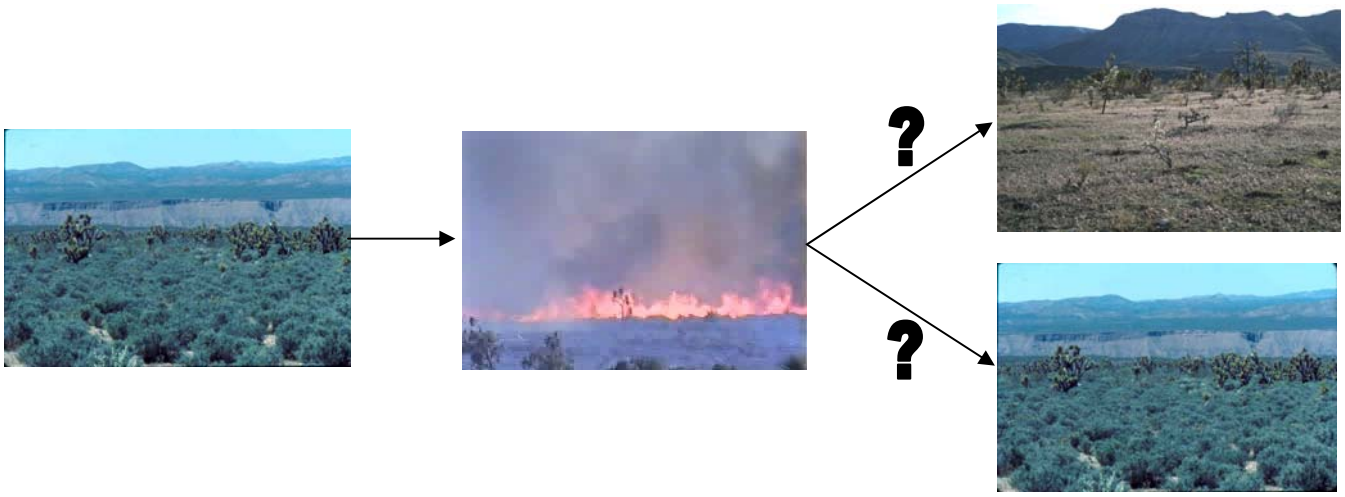
[2] Office of Secretary of Defense, Strategic Environmental Research and Development Program/Environmental Security Technology Certification Program

Climate change has the potential to significantly impact the Department of Defense's (DoD) ability to sustain training and testing missions and to maintain military readiness. Maintaining readiness requires a natural and built infrastructure that is sustainable and adaptive in the face of climate change. To assist DoD in this regard, the DoD's Strategic Environmental Research and Development Program (SERDP) has moved aggressively to fund research and development (R&D) projects that assess impacts and vulnerabilities and explore approaches to reduce these impacts through adaptation and mitigation. Ongoing and future SERDP projects will equip DoD with the information, analyses, models, and tools needed to meet its mission and stewardship responsibilities now and into the future. Improving scientific understanding and developing models and predictive tools to assess the impacts of climate change are critical tasks – whether the time frame of concern is near-term, 20 years from now, or out to 2100 and beyond. This article focuses on those SERDP projects that relate to natural resources and climate change.

Understanding impacts and adapting to climate change is of interest in a number of regions in which DoD installations reside. For example, in the Southwest climate change is likely to result in region-specific changes in temperature, precipitation regimes, and extreme weather events that may exacerbate the degradation of southwestern ecological systems of management concern. Three SERDP projects, which in combination encompass study sites in the Mojave and Sonoran Deserts, are examining the interactions between non-native invasive species (NIS), fire regimes, and climate change. Collectively, these projects are elucidating NIS colonization strategies, refining empirically-based models of NIS invasion in the face of changing fire regimes, and developing an understanding of NIS distribution after fire events have occurred. All of the preceding also will be evaluated in the context of climate change. The results of this work will improve our understanding of how these interactions, today and into the future, affect the composition, structure, and function of ecological systems in the Southwest. Predictive models developed by these projects also will enable the development of appropriate adaptive management strategies.



Desert scrub ecological systems in the Southwest are not adapted to fire. The presence of non-native invasive species, exacerbated by climate change, creates an uncertain future for resultant fire regimes and their impact on these systems.

Climate change in the Southwest also is likely to exacerbate the degradation of intermittent and ephemeral stream systems, important harbingers of the region's biodiversity that are already stressed by human population pressures and associated land-use activities, altered hydrologic regimes, and NIS. Four SERDP projects are addressing these issues at different spatial scales across the Southwest. Research sites are located across the Sonoran, Mojave, and Chihuahuan Deserts, as well as in the Sky Island/Semidesert Grassland region of southeastern Arizona. These sites represent a gradient of intermittent and ephemeral stream ecological conditions and settings that will enable us to better understand the ecology and management of these systems. Site selection and coordination across projects will allow detailed study and comparisons of what can be learned about ecological function within individual study sites and a broader study of a cross-section of study sites across the region to characterize regional diversity. These different lenses should enable better optimization of management recommendations that result from the combined work. These projects will ultimately provide installations in the Southwest with the fundamental knowledge, strategies, and tools needed to adaptively manage southwestern intermittent and ephemeral stream systems facing current and future stressors such as climate change.

Yuma Wash, Yuma Proving Grounds, AZ — Ephemeral Flow

Longleaf pine stands exhibiting different reference conditions.

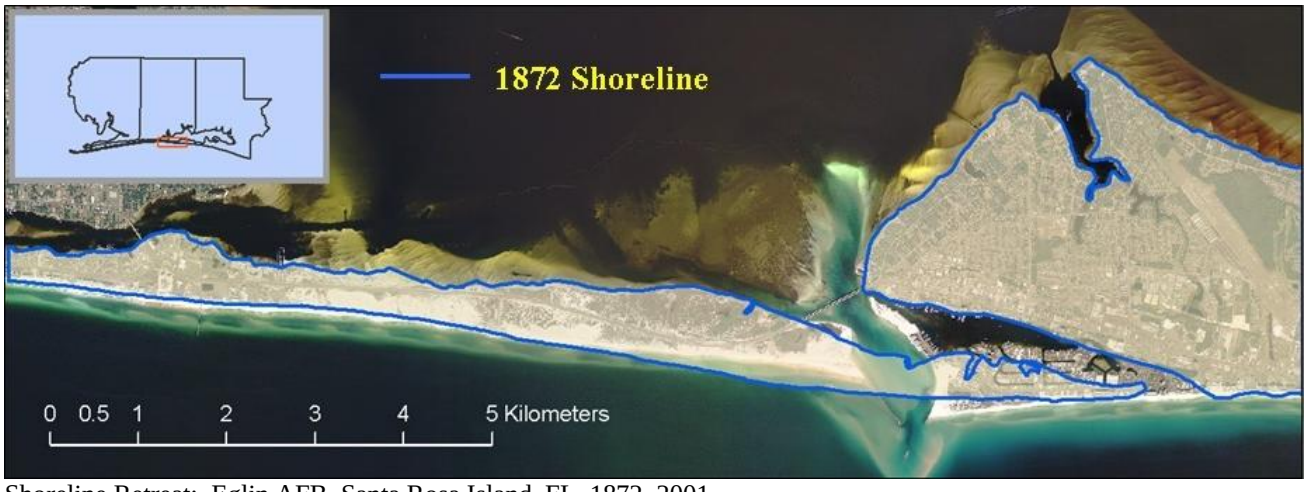
In the Southeast, where DoD natural resources managers are engaged in the long-term management and restoration of ecological systems and threatened, endangered, and at-risk species, such efforts may be limited by the synergistic effects of climate change on already stressed ecological systems. SERDP-funded research in this region focuses on improving our understanding of the potential impacts of climate change on the ecological systems and species of the region and in starting to address potential adaptation strategies to climate change. In addition, the focus has been on both coastal ecological systems and terrestrial/inland ecological systems.

More specifically, SERDP researchers have begun to develop recovery objectives for southeastern ecological systems, including longleaf pine sandhill communities, longleaf pine savannah plant communities, and blackwater streams, all of which represent key habitat areas for threatened, endangered, and at-risk species in this region. These science-based recovery objectives will be achieved by (1) constructing ecological reference models to aid in defining recovery objectives; (2) building assessment frameworks to determine the feasibility of recovery, aid in the selection of appropriate recovery strategies, and provide a structure for measuring progress towards meeting recovery objectives; and (3) assessing the impacts of climate change on setting recovery objectives.

Southeast military installations located in the coastal zone present unique land management challenges under climate change, as the threat of sea level rise (SLR) in association with potentially modified storm conditions introduce additional constraints to ecological system management and recovery. At present, SERDP researchers are concentrating their climate change adaptation efforts on those species and habitats most vulnerable to climate change by developing tools for assessing potential options to manage shoreline-dependent bird species and evaluating assisted colonization as a management tool for coastal transition zone plant species subject to increased levels of storm surge. In addition, as part of SERDP's Defense Coastal/Estuarine Research Program, researchers are assessing whether coastal marsh plants can grow and accumulate sediments at a pace comparable to the rate of SLR. They also are evaluating the feasibility of supplementing marsh plants with additional nutrients as a mechanism to ensure coastal wetland sustenance over time when the marshes otherwise can't stay ahead of SLR.

Snowy Plover—A shoreline dependent bird species in the Southeast.

Sea level rise and associated storm surges that may be exacerbated by climate change also pose a threat to the built infrastructure on DoD's coastal installations. To address this threat, SERDP research is focused on developing region-specific models and tools to better understand the physical drivers and processes that determine how sea level change and storm surge will manifest under climate change and how landscapes will respond. A suite of projects is examining scenarios of 0.5, 1.0, 1.5, and 2.0 meter local mean SLR, achieved by 2100, to assess the potential impacts of SLR and storm surge to U.S. Southwest Pacific, Mid-Atlantic, and Gulf Coast installations. Biophysical features, such as barrier islands and marshes, provide both habitat for species of concern and protection for coastal infrastructure. Their presence and how they respond to physical drivers complicates our understanding of how coastal areas will be impacted by rising seas and increased storm surge. By combining improved knowledge of these phenomena with tools to assess mission critical assets, DoD installations will be better able to predict vulnerabilities and impacts to the natural and built features that protect coastal areas and the resultant effects on critical missions and stewardship. The results of these projects also will help DoD installations begin to understand their options and need for adaptation.



Shoreline Retreat: Eglin AFB, Santa Rosa Island, FL, 1872–2001.

Efforts to mitigate DoD's contributions to climate change are ongoing in SERDP and its sister program, the Environmental Security and Technology Certification Program (ESTCP). The current focus is on improving DoD's energy conservation and efficiency, increasing its use of renewable energy, and improving land management practices. Advances in these areas will directly reduce our carbon footprint and enable DoD to achieve an appropriate balance between carbon sequestration and other desired ecosystem services.

SERDP continues to make climate change R&D a top priority in the Sustainable Infrastructure focus area, as evidenced by two new FY 2011 SERDP Statements of Need. The first, Impacts of Climate Change on Alaskan Ecological Systems, expands SERDP's coverage of climate change research to cold regions. Climate change in Alaska has the potential to significantly alter ecological systems of management concern to DoD. Changes in the freeze-thaw cycles associated with permafrost, for example, could result in a diminished capacity to support mission and stewardship requirements. The second, Ecological Forestry and Carbon Management, sets the stage for additional SERDP R&D in climate change mitigation. Understanding the carbon cycle for DoD forested ecosystems is critical to identifying how ecologically based forest management versus other land uses contributes to an installation's carbon footprint and the trade-offs associated in providing other ecosystem service benefits while still maintaining biodiversity. For additional details on the FY 2011 SERDP solicitation, please visit http://www.serdp.org/Funding/index.cfm.

Climate Change and Bats: Vampire bats offer clues to the future

By Dr. Shahroukh Mistry[1] and Dr. Arnulfo Moreno-Valdez[2]
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[2] Instituto Tecnológico de Ciudad Victoria, Mexico

Overheated flying foxes, panting and frantically fanning themselves with their wings, fell from the trees in New South Wales, Australia, six years ago. Up to 3,500 black and grey-headed flying foxes died on the ground beneath their roosts, victims, researchers believe, of heat waves that pushed temperatures to 108 degrees F (42º C). In this era of looming climate change, such scorching temperatures are occurring more often and with tragic consequences: since 1994, more than 30,000 flying foxes have died in New South Wales, apparently because of at least 19 episodes of extreme heat.

Such sudden and massive mortality is an unusual result of global climate change, at least so far. Current and likely future impacts are being studied for many species of wildlife, from frogs to polar bears. Research into the effects on bats lags behind, although nothing suggests bats will be spared the impacts of transformed environments.

Common vampire (*Desmodus rotundus*)
Photo: Adrian Warren

To begin examining some probable impacts of climate change on bats, we chose the common vampire bat (*Desmodus rotundus*) – an opportunistic species that is especially sensitive to low temperatures. One of only three bat species that feed on blood, the common vampire (limited to Mexico, Central and South America) will probably see its range expand dramatically northward. And it will bring a number of challenges along with it.

At least as important as projected increases in worldwide temperature averages is a predicted increase in variability at the climatic extremes. Severe weather events will likely increase in both frequency and intensity, with potentially grim consequences for countless species. As our understanding of these effects increases, so does our ability to predict impacts and to protect vulnerable species before insurmountable problems occur.

Rising temperatures already have demonstrably changed habitats and distributions of many animal species, typically by shifting them poleward. Examples include Edith's checkerspot butterfly, which has lost 80 percent of its southern and low-elevation populations in North America, and the red fox, which has moved so far north it now competes with the Arctic fox. The rufous hummingbird once wintered almost exclusively in Mexico, with fewer than 30 annual sightings in the United States from 1900 to 1990. By 1996, there were 1,643 sightings.

Variations in when plants flower and fruit affects the timing and availability of resources, as well as the migratory and reproductive patterns of many fruit- and nectar-eating bats. Many plants and bats have co-evolved symbiotic relationships, with bats providing pollination and seed-dispersal services as they feed on the plant's flowers and fruit. So if migrations and blooming cycles fall out of sync, both plants and pollinators are threatened. This is already seen in some bird species. Changes in plant resources may also have an indirect effect on insect-eating bats by altering the timing and abundance of prey.

Only a handful of studies have specifically examined climate change and bats, and they strongly suggest that bats will be affected at least as much as other organisms. In Costa Rica, bats have recently been documented at higher-than-normal elevations, and the wintering range of bats in North America is expected to keep expanding northward. An analysis of U.S. national parks suggests that most will see a high turnover of species because of changing habitats and a reduction of up to 20 percent in the number of mammal species present, with bats accounting for about one-fifth of the lost species.

Changes in temperature may affect hibernation periods and the availability of suitable hibernacula in the future. Increased variation in climatic extremes raises the possibility of bats emerging from hibernation early or at a greater frequency. That would not only put hibernating bats at risk from depleted energy stores, but could also affect the birth and survival of pups. Resources, especially insect prey, may be limited or variable during periods of early arousal from hibernation.

It is too early to say whether White-nose Syndrome, the recent and dramatic mortality of hibernating bats in the northeastern United States, is linked to climate change. But a general increase in the incidence of diseases – as changing climate allows pathogens to expand their range northward – is a possibility that has been reported in amphibians and other organisms.

Among the most likely future impacts are changes in the range of migratory species, as are already evident with Nathusius' pipistrelle (*Pipistrellus nathusii*), recently recorded in Poland for the first time during winter, and eastern red bats (*Lasiurus borealis*), found farther west than ever in Saskatchewan, Canada.

The ranges of many bat species are restricted by the bats' inability to tolerate certain conditions. The common vampire bat, for example, is sharply limited by low temperatures. It cannot consume enough blood to maintain its body temperature when the ambient temperature falls below 50 degrees F (10º C). Studies suggest that the northern and southern limits of its range are determined primarily by the lowest temperatures of winter. Thus the bat's current distribution in Mexico – from the southern part of the country and midway up the coastlines – closely matches those areas of Mexico where wintertime lows remain above this threshold.

This strict physiological limitation makes *Desmodus* an excellent model for studying how animals respond to climate change. Given suitable habitat and resource availability, the species' northward movement should closely track the 50-degree F winter isotherm on weather maps.

Climate change models predict that average temperatures are likely to increase by 3 to 5 degrees F (1.7º to 2.8º C) along the Texas-Mexico border by 2080 and could rise as much as 7 degrees F (3.9º C) in parts of Texas. Given this increase in average temperatures, winter minimums should also increase, opening new areas of northern Mexico and the southern United States to the common vampire bat.

We are using global climate change models to study how winter minimums are likely to change along the U.S./Mexico border and have built a predictive model to understand how the vampire bat may expand its range. These models allow us to examine temperature changes over the next 75 years and identify locations that are most likely to be suitable for these bats.

Our initial results suggest that over the next few decades, the 50-degree F isotherm – and thus the potential distribution of *Desmodus* – probably will expand significantly along the east and west coasts of Mexico and into the southern tip and Gulf Coast of Texas, possibly including lower Louisiana. Additionally, disjunct areas of suitable temperature, such as the southern half of Baja California and Florida and isolated locations in Arizona and California, could also become potential vampire-bat habitat.

The size of this bat's range is expected to increase by at least 100,000 square miles (260,000 square kilometers) – one-third larger than its current Mexico range. And as warming extends to higher elevations, *Desmodus* likely will occupy almost the entire southern and coastal regions of Mexico, as well as the central mountain ranges where it previously did not venture.

Recent anecdotal reports suggest that these bats already have reached farther north than current models predict. We suspect the bats may be exploiting microclimatic differences between ambient and roost temperatures. That is, they are able to move into areas that have cooler average temperatures by roosting at specific sites where temperatures remain above their threshold. We are testing this hypothesis by measuring wintertime roost temperatures and will calibrate our distribution model based on these data.

Common vampires are also being reported farther north and at higher elevations of central Mexico than previously documented. This range expansion likely is aided by increasing habitat fragmentation in Mexico, which is expected to extend the distribution of opportunistic species such as *Desmodus*.

The possible movement of common vampire bats into the United States would present challenges on many fronts: ecological, commercial, medical and educational. These include probable impacts on other bat species, the livestock industry, and public health concerns. Perhaps the most important impact might be increasingly negative views among the public about all bats; countless beneficial bats are killed throughout *Desmodus*' range in mistaken efforts to eliminate vampire bats. Understanding how and when these bats might expand into the United States should give us time to prepare and educate before problems arrive.

The vampire bats' response to the changing climate should also give us hints about how the ranges of some other bats might be altered. We expect to see changes in the range and migration timing of some bat species and fear that some species may be lost. The next few decades will be extremely challenging for scientists trying to discern critical impacts of climate change and the rapid alterations in species distributions and interactions that it will cause.

Scientists who study ecological processes, which mostly occurred gradually over long periods of time, are learning to deal with the more abrupt changes driven by human activity, such as clearing the rainforests. This is akin to watching a movie and trying to examine each individual frame. Climate change alters all that: the film is stuck on fast forward. Immense impacts seem to be charging towards us. We need to identify exactly what is coming and prepare to deal with it.

This article first appeared and is adapted from the Summer 2008 issue (Vol. 26, No.2) of BATS Magazine (Bat Conservation International, http://www.batcon.org.)

Climate Change's Impact On Bird Species

By Jeff Price[1], Steve Holmer[1], and Patricia Glick[2]
[1] American Bird Conservancy
[2] National Wildlife Federation

Climate change will make survival more difficult for many bird species and other wildlife. Between 20–30% of all species are at an increased risk of extinction if average temperatures increase more than 2.5°C., according to the report *Climate Change 2007: Impacts, Adaptation and Vulnerability* (www.ipcc.ch/SPM6avr07.pdf) by the Intergovernmental Panel on Climate Change (IPCC).

Like many plants and animals, birds' life cycles and behavior are closely linked with the changing seasons. For neotropical migrant species, including many warblers, vireos, and other songbirds, changes in temperature, daylight periodicity, and wind signal when they should begin their long flights southward in the fall and back again in the spring. Variables such as temperature and precipitation also affect the timing and availability of flowers, seeds, and other food sources when birds reach their stopover locations and destinations.

Much of the habitat for the Golden-cheeked Warbler, *Dendroica chrysoparia*, is found at Fort Hood, TX. This species could become extinct if their habitat disappears due to climate change. Photo courtesy of USFWS

Moreover, birds that rely on very specific habitats for at least part of their life cycle, such as the endangered Golden-cheeked Warbler in Texas, could become extinct if their habitat disappears. For each of these reasons, many bird species are considered to be particularly vulnerable to climate change.

Climate Change Is Already Affecting Some Species

Studies indicate that the ranges of a number of bird species have been changing, consistent with the 20th century trend of rising average temperatures. (See population distribution maps for American Goldfinch below). Bird populations are expected to shift poleward or to higher elevations to stay within their ideal temperature and habitats as the climate changes.

At least seven North American warbler species (Prothonotary, Blue-winged, Golden-winged, Black-throated Gray, Pine, Hooded, and Cape May Warblers) are documented to have shifted their range north in the past 24 years, by an average of more than 65 miles.

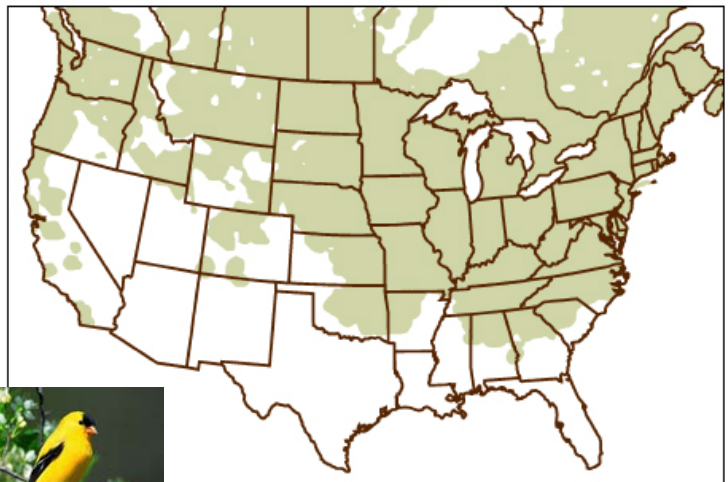
As many as 80 species native to Texas have moved north or eastward in the last 30 years, including tropical species such as Great Kiskadee, Buff-bellied Hummingbird, White-tipped Dove, and Tropical Parula. The Green Jay, an especially sedentary species, has been spotted 60 miles north of its original range.

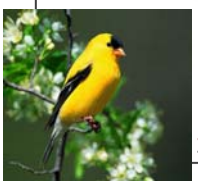
The Tufted Titmouse, Blue-gray Gnatcatcher, Northern Mockingbird, and Red-bellied Woodpecker have increased in number and have expanded their range northwards in Ontario compared to 20 years ago.

Seabirds such as the Sooty Shearwater have shifted their migration routes toward cooler northwestern areas of the Pacific in response to rising sea temperatures off the coast of California. There are also signs that recent climate trends are affecting birds' behaviors. Studies in the United States and Europe have found that some songbirds are migrating earlier in spring, corresponding with warmer temperatures.

A study of twenty species of migratory birds in North America shows that spring arrival dates were up to 21 days earlier in 1994 than in 1965, while just a few species were later. Many species, including the Tree Swallow, are now nesting up to nine days earlier than 30 years ago.

CURRENT POPULATION DISTRIBUTION OF THE AMERICAN GOLDFINCH

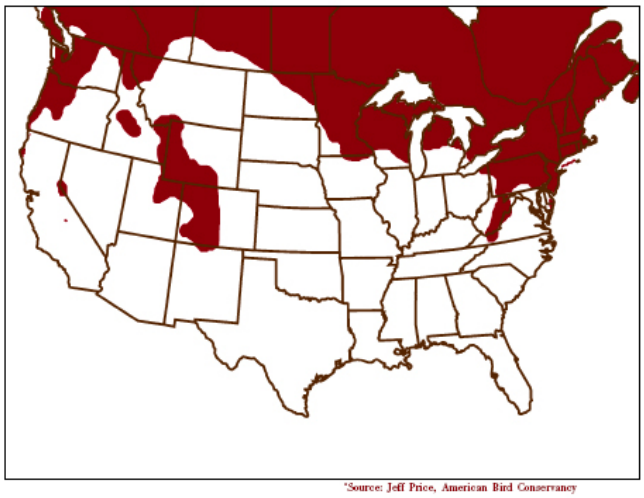




American Goldfinch
-U.S. Fish and Wildlife Service

*Source: Jeff Price, American Bird Conservancy

PROJECTED POPULATION DISTRIBUTION OF THE AMERICAN GOLDFINCH (2 x CO_2)



*Source: Jeff Price, American Bird Conservancy

Because this shift is occurring throughout the species' broad habitat ranges, scientists believe that the birds are responding to larger trends than just localized climate variations. These changes may be occurring regardless of whether a bird's arrival is synchronized with the availability of food sources such as insects, flowers, and berries at its migratory destinations. As a result, climate change may cause migration and nesting to get out of step with food supplies.

Scientists at the Rocky Mountain Biological Laboratory in Colorado have discovered that American Robins migrating to the region arrive an average of two weeks earlier than they did 23 years ago. They attribute this shift to the likelihood that the birds are responding to warmer temperatures at the lower altitudes that typify their wintering grounds.

Effects of Climate Change on the Distribution of Songbirds in the United States

Bird communities, as we currently know them, may look quite different in the future if we do not begin to take meaningful action to reduce the greenhouse gas emissions responsible for climate change. As regional temperatures rise, the ranges of a number of species in the Northern Hemisphere could shift north as they seek habitat, food, and other factors to which they are adapted.

When species move to different ranges, they may face new predators and competitors, as well as different habitats and prey. So-called "optimal" habitats for many species may no longer exist, at least in the short term. This is particularly true for birds relying on specific plants for food or nesting. While most birds can respond quickly to a changing climate, the ranges of some plants may take centuries to move, if they move at all.

Climate Change Could Lead to a Decrease in Neotropical Migrant Species in the United States

Research has shown climate change will likely change the number of neotropical migrant species present in different regions of the country. For example, the Great Lakes region could see a gross loss of 53% of the neotropical migrant species that are currently found there. These losses may be somewhat offset by new bird species colonizing from outside the region—Painted Buntings and Great-tailed Grackles replacing Bobolinks and Evening Grosbeaks in parts of southern Minnesota, for instance—so the net change might be 29% fewer neotropical species than are currently found there. This analysis suggests that each region of the country could see a net decrease in neotropical migrant species present if climate change continues unabated.

New York could see a significant reduction in Cape May Warblers, Bay-breasted Warblers, and other birds that are important predators of pest insects such as eastern spruce budworms, which can cause major damage to the state's forests.

Arizona, Nevada, and New Mexico could lose Savannah Sparrows, Sage Thrashers, and other birds that help keep outbreaks of grasshoppers in check. Some states may even lose their state birds. If climate change continues unabated, there may no longer be Baltimore Orioles in Baltimore (or anywhere else in Maryland).

Climate Change Causing Habitat Loss and Alteration

Climate change has damaged natural habitats of many bird species from the Caribbean to the poles. Lower latitudes have experienced more intense storms and droughts as a result of climate change, and this trend is expected to increase. These extremes will damage tropical forests already decimated by logging, agriculture, and development.

Recently, on the West Coast unusually large numbers of dead Common Murres, Rhinoceros Auklets, and Tufted Puffins washed up on beaches in California, Oregon, and Washington. In 2005, large numbers of Cassin's Auklets also died. These deaths over the winter were followed by less successful breeding seasons. The trend appears to be linked to warmer waters which support less plankton, and thus provide less food for seabirds.

The Kittlitz's Murrelet has decreased by 97% in the past 30 years. The small bird nests near coastal glaciers, where it feeds on plentiful krill and small fish. However, as glaciers melt they cause excessive sedimentation, making it difficult for the bird to find food. In addition, the glaciers release fresh water, which decreases ocean productivity.

Many species of arctic wildlife rely on ponds that are drying up after 6,000 years. The ponds are a source of fresh water, making them essential to breeding success. Research shows these ponds are now thawing earlier in the spring and evaporating as a result of warmer temperatures.

Did You Know? Kittlitz's Murrelet is a small, rare seabird found only along the coasts of Alaska and northern Asia. Preferred habitat is ice-choked fiords near tidewater glaciers, where they dive for small fish, although breeding populations also occur in places where no glaciers are present. Climate change may be having a negative effect on the species through habitat loss and reduction of preferred prey species.

Sea level rise could inundate important coastal habitat in many places. Without meaningful action to reduce greenhouse gas emissions, climate scientists project that sea levels could rise by 10.9 inches to 30.8 inches this century. This would have major implications for the more than 150 species of migratory waterfowl, shorebirds, and other birds that rely on coastal marshes in the mid-Atlantic region for nesting, feeding, or roosting. For songbirds and other wildlife whose populations are already limited by other human-induced problems, climate change could be the last straw.

Habitat Protection—an Important Part of the Climate Change Solution

The IPCC report found that an important way to mitigate the impacts of climate change is to protect existing forests, grasslands, and wetlands, which store carbon and provide essential habitat for imperiled wildlife. At least 20% of greenhouse gas emissions result from deforestation, which causes carbon stored in forest biomass, deadwood, litter and soil to be released to the atmosphere. The by-product of a global program to reduce greenhouse emissions through forest conservation would be the protection of large numbers of Earth's threatened species, and preservation of ecosystem services such as watersheds. "Avoided deforestation," in which payments are provided to countries or projects that protect existing forest, can be financed by carbon taxes, a global trust fund, or by carbon credits purchased by polluters to offset emissions.

This article is adapted from and was first published by the American Bird Conservancy. The material in this article is based on the "The Birdwatcher's Guide to Global Warming", a 2002 report published by American Bird Conservancy and the National Wildlife Federation (available at www.abcbirds.org/newsandreports/birdguide.html) and Climate Change 2007: Impacts, Adaptation and Vulnerability (http://www.ipcc.ch/SPM6avr07.pdf) by the Intergovernmental Panel on Climate Change (IPCC).

For More Information, see the American Bird Conservancy website, www.abcbirds.org. The State of the Birds USA 2010 report, available March 2010 on www.nabci-us.org, will feature the impact of climate change on birds.

Call for Articles for Natural Selections

We'd like to know what's been working well for you – other readers might find some timely hints! Send us your Success Stories, large or small. Second, we invite your contributions to our Themed Issues. This month, we are focusing climate change. The themes and deadlines for the remainder of 2010 are:

Issue	Theme	Article Due Date	Expected Publication Date
February	Invasive Weeds	January 22	February 1
March	HI-Pacific	February 19	March 1
April	Herps	March 19	April 5
May	Birds: Migrants and/or Breeding Habitat	April 21	May 3
June	Pollinators	May 20	June 7
July	Fisheries	June 22	July 6
August	Wetlands	July 16	August 2
September	Wildlife Disease	August 20	September 7
October	Forestry	September 17	October 4
November	Corridors/Connectivity	October 15	November 1
December	Ecosystem Services	November 19	December 6

Training, Announcements & Events of Interest

Workshops, Interagency Training Announcements, and Future Events of Interest to the Conservation Community

10th National Conference on Science, Policy, and the Environment: The New Green Economy: January 20-22, 2010 in the Ronald Reagan Building and International Trade Center in Washington, DC. The National Council for Science and the Environment's National Conference engages leading thinkers and doers from a diversity of disciplines, sectors, and perspectives in a structured conversation about the meaning of the green economy and how investments in green education, research, and jobs can help to solve both the economic and environmental crises. For more details and registration, visit: http://ncseonline.org/conference/GreenEconomy/.

Designing and Delivering A Training Session (LED5109): February 1-5, 2010 at the National Conservation Training Center, Shepherdstown, WV. This train-the-trainer course teaches curriculum developers and/or instructors how to design an effective training session and includes the opportunity to practice effective presentation and classroom management skills. It covers the fundamentals of instructional design, adult learning principles, writing objectives and lesson plans, and interactive strategies to engage participants in learning. It also includes an overview of the instructional design cycle including needs analysis, development, content design, delivery and the five levels of evaluation. Class registration: https://doilearn.doi.gov/ and search the catalog for "LED6102". Course content questions: Jack Owens at (304) 876-7903 or Jack_Owens@fws.gov; course registration questions: Tannor Kopp at (304) 876-7477 or Tannor_Kopp@fws.gov.

Sampling Large Landscapes and The Coordinated Bird Monitoring Database: February 4 - 5, 2010 at the Colorado Belle Casino, Laughlin, NV. The workshop will briefly demonstrate a suite of tools for estimating population size and density, and for exploring habitat relationships. The tools were developed during the past decade, first in the Arctic and more recently in the southwestern United States. They include an ArcView extension used to delineate plots, assign them to clusters and strata and select plots to survey; description of double sampling as an "umbrella" survey method; a comprehensive program to analyze the survey data; and a database for long term storage of the data. All of the programs and services are available free of charge. The workshop will be presented by Jonathan Bart (US Geological Survey) and Leah Dunn (Great Basin Bird Observatory). It was organized for Bureau of Reclamation personnel but anyone is welcome to attend. There is no registration charge. Rooms are available at low cost in Laughlin but there are no plans for reserving a block of rooms. Participants should bring a laptop. Please send a note to Leah Dunn at ldboise@gmail.com letting her know you plan to attend.

2010 DoD Pest Management Workshop: Operational Pest Management, New Confrontations with Old Foes: February 8-12, 2010, Naval Air Station, Jacksonville, Florida. This workshop will include several symposia, vendor displays, social events and a Plenary Session. Registration for the workshop is electronic: please visit http://www.afpmb.org/workshopregistration and complete the online form. A general information page, including workshop agenda and lodging information for the Tri-Service Workshop is now available on the Armed Forces Pest Management Board's web site: http://www.afpmb.org/meetings/TriService2010/info.htm.

Migratory Bird Conservation: A Trust Responsibility (ECS2102): February 22 - 26, 2010, National Conservation Training Center, Shepherdstown, WV. This course is designed to give participants a working knowledge of the legal and conservation implications of the Migratory Bird Treaty Act. Partnerships, resources and initiatives that address migratory bird conservation are explored in detail, providing participants an excellent overview of how they can further implement migratory bird conservation. The course includes a field trip with bird walk and mist-netting demonstration. To register, visit the online registration site (http://training.fws.gov/learn/courses.htm) and type the course code (ECS2102) in the search box. Contacts: For registration: Brenda Hooper, NCTC Phone: 304/876-7449 (brenda_hooper@fws.gov). For content: Karene Motivans, Course Leader, NCTC Phone: 304/876-7458 (karene_motivans@fws.gov).

Funding Available for Environmental Research and Development: The Department of Defense's (DoD) Strategic Environmental Research and Development Program (SERDP) is seeking to fund environmental research

and development in the Sustainable Infrastructure focus area. The development and application of innovative environmental science and technology supports the long-term sustainability of DoD's installations and ranges, as well as significantly reduces current and future environmental liabilities. The Sustainable Infrastructure focus area concentrates on natural resources, cultural resources, and the sustainable management of DoD facilities. SERDP intends to fund multiple projects that respond to the following four focused Statements of Need (SON) in Sustainable Infrastructure:

1. Impacts of Climate Change on Alaskan Ecological Systems
2. Behavioral Ecology of Cetaceans
3. Ecological Forestry and Carbon Management
4. Ecology and Management of Source-Sink Populations

Proposals responding to the Fiscal Year (FY) 2011 SONs will be selected through a competitive process. Pre-proposals from the non-federal sector are due by **Thursday, January 7, 2010**. Proposals from the federal sector are due by **Thursday, March 11, 2010**. The SONs and detailed instructions for federal and private sector proposers are available on the SERDP web site at www.serdp.org/funding.

Sustainable Military Lands Management Certificate: This Colorado State University three-course online certificate will train you in the breadth and complexity of military land management and provide you with knowledge of the rapidly evolving practices, technologies, and analytical tools necessary to support this national defense mission. For more information on this certificate or about registration, please contact Jenny Hannifin at 970-491-2665 or jhannifin@learn.colostate.edu.

FREE Web Seminars on Inventory and Survey Methods for Invasive Plants: Six FREE interactive web seminars on inventory and survey methods for invasive plants are offered by the Center for Invasive Plant Management during January and February 2010. There is no fee for the seminars, but advanced registration is required. Participants will be provided with reading materials in advance of each seminar. To learn more and register, visit http://www.weedcenter.org/outreach/project-webseminar.html.

NatureServe Conservation Conference 2010— Biodiversity Without Boundaries: Celebrating the International Year of Biodiversity: April 26–28, 2010, in Austin, Texas. The NatureServe Conservation Conference 2010: Biodiversity without Boundaries will explore the issues and solutions to these and related conservation needs on several fronts: the science behind the pressing problems, the information and expertise needed to direct decisions, the tools and methods for setting priorities and tracking progress, and the lessons learned from conservation success, collaboration, and leadership approaches. To register, visit: http://www.regonline.com/natureserve_2010.

37th Annual Natural Areas Conference: Connecting for the Future Across Generations and Disciplines: October 26 - 29, 2010 at Tan-Tar-A Resort, Osage Beach, Missouri. This national conference will bring together natural resource professionals, students, and volunteers in a forum that provides practical, land management focused information through symposia, workshops, field trips, paper sessions, posters, round tables, and opportunities for social networking. The progressive conference program will connect new tools, places, and faces amongst a diverse audience of land managers, university faculty and students, researchers, planners, and administrators from throughout the nation who are involved with the conservation and management of natural communities. The mainstay of this annual national conference has been strong participation from local, regional, and national organizations and agencies. For more details visit: http://www.naturalarea.org/ or contact Mike Leahy at (573.522.4115, ext. 3192) or mike.leahy@mdc.mo.gov.

Recent Natural Resources Documents Online

Reports, Fact Sheets, Photos, Videos

This section highlights recently uploaded reports and factsheets on the Legacy Tracker or on the DENIX website. For Legacy related products, please visit https://www.dodlegacy.org/Legacy/intro/ProductsList_NU.aspx. All Legacy products and many more are available at https://www.denix.osd.mil/portal/page/portal/denix/environment/NR. In addition to these two websites, bird-related products are also posted on http://www.DoDPIF.org.

Establishing American Chestnut Test Orchards on Two TN Army National Guard Installations: (Legacy 08-401) Contributing to the Efforts to Restore an Ecological and Cultural Giant to the Forest Ecosystems of the Eastern United States, Report. October 23, 2009: American chestnut (*Castanea dentata*) was once one of the dominant trees in the eastern forests of the United States. By 1950, this keystone species on an estimated 9 million acres of eastern forest had all but vanished as a result of blight infection. The purpose of this project is to contribute to the efforts to develop a blight-resistant American chestnut that may be reintroduced into its former habitat across the eastern United States by establishing seed orchards on two Tennessee Army National Guard (TNARNG) facilities: VTS-Milan and VTS-Catoosa. This report describes the methodologies in producing the crosses and establishing the orchards. https://www.denix.osd.mil/portal/page/portal/NaturalResources/OtherConservationTopics(A-H)/HabitatRestoration

Fact Sheet: Establishing American Chestnut Test Orchards on Two TN Army National Guard Installations: (Legacy 08-401).Contributing to the Efforts to Restore an Ecological and Cultural Giant to the Forest Ecosystems of the Eastern United States https://www.denix.osd.mil/portal/page/portal/NaturalResources/OtherConservationTopics(A-H)/HabitatRestoration

Brochure: American Chestnut Orchards and the Tennessee National Guard- Utilizing military initiative to support restoration efforts: (Legacy 08-401): this outreach publication nicely summarizes the history of the plight of the chestnut, efforts to save the species and the military's part in the restoration efforts. https://www.denix.osd.mil/portal/page/portal/NaturalResources/OtherConservationTopics(A-H)/HabitatRestoration

Slideshow: Establishing American Chestnut Test Orchards on Two Tennessee Army National Guard Installations: This presentation shows all the steps taken (from clearing to seedling) in establishing the chestnut orchards on 2 TN Guard installations. Contains great images. https://www.denix.osd.mil/portal/page/portal/NaturalResources/OtherConservationTopics(A-H)/HabitatRestoration

Invasive Species Guidebook for Department of Defense Installations in the Delaware River Basin: (Legacy 08-328) This report provides a guide for invasive plant species identification, management techniques, a how to guide on preventing recurring invasive species and restoring historical plant communities, forming cooperative partnerships to achieve management goals, and case studies. https://www.dodlegacy.org/Legacy/intro/ProductsList_NU.aspx

Grassland Restoration and Management Plan for the Repatriation of the Regal Fritillary Butterfly (*Speyeria idalia*): (Legacy 08-392) In 2007-2008, the Pennsylvania Department of Military and Veterans Affairs Wildlife Office entered into an agreement with multiple landholding agency partners to restore native grasslands, an effort to repatriate the regal fritillary butterfly (*Speyeria idalia*) to landholdings having a historic occurrence or probable occurrence. The objectives of the project are to establish native warm-season grassland habitat to benefit a multitude of species including, the regal fritillary, and to establish long-term sustainable breeding populations of regal fritillaries outside of DoD managed lands. https://www.dodlegacy.org/Legacy/intro/ProductsList_NU.aspx

Pollinators Fact Sheets: What Can You Do To Help and The Facts About Pollinator: Both of these factsheets can now be found at https://www.denix.osd.mil/portal/page/portal/NaturalResources/OtherConservationTopics(A-H)/EcosystemServicesandEcosystemManagement and at http://dodpollinatorworkshop.com.

Photo of the Month

Capturing the beauty of our natural resources

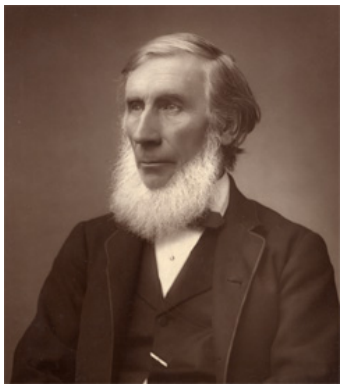
January 2010 Photo of the Month Winner!

Brown Pelican at Cape Canaveral Air Force Station, Florida.
Submitted by *Natural Selections* reader: Richard Fisher
U.S. Army Corps of Engineers – Engineering Research and Development Center, Missouri

Did You Know?

Little Did You Know Conservation Could Be So Much Fun!

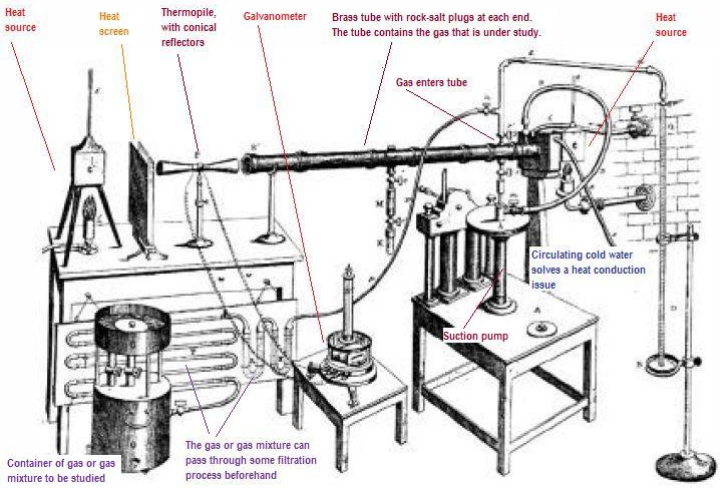
Did you know…CO_2 as a greenhouse gas was proven long time ago! John Tyndall, born in Ireland August 2, 1820 was a prominent 19th century physicist and geologist. His initial scientific fame arose in the 1850s from his study of diamagnetism. Later he studied thermal radiation, and produced a number of discoveries about processes in the atmosphere.



John Tyndall, c. 1885.

The greenhouse effect is the heating of the surface of a planet or moon due to the presence of an atmosphere containing gases that absorb and emit infrared radiation. Thus, greenhouse gases trap heat within the surface-troposphere system. This mechanism is fundamentally different from that of an actual greenhouse, which works by isolating warm air inside the structure so that heat is not lost by convection. The greenhouse effect was discovered by Joseph Fourier in 1824, first reliably experimented on by John Tyndall in 1858, and first reported quantitatively by Svante Arrhenius in 1896.

What would be described in today's standards as very rudimentary equipment, the figure at the bottom shows John Tyndall's equipment setup for measuring the relative radiant-heat absorption of gases and vapors. The galvanometer quantifies the difference in temperature between the left and right sides of the thermopile. The reading on the galvanometer is settable to zero by moving the Heat Screen a bit closer or farther from the left-hand heat source. The right-hand heat source directs radiant heat into the long brass tube. The long brass tube is highly polished on the inside, which makes it a good reflector (and non-absorber) of the radiant heat inside the tube. Rock-salt (NaCl) is practically transparent to radiant heat, and so plugging the ends of the long brass tube with rock-salt plates allows radiant heat to move freely in and out at the tube endpoints, yet completely blocks the gas within from moving out.



John Tyndall's equipment used in his experiments that eventually helped him prove earth's atmosphere played a major role in absorbing radiant heat, the greenhouse effect.

To begin the measurements, both heat sources are turned on, the long brass tube is evacuated as much as possible with an air suction pump, the galvanometer is set to zero, and then the gas under study is released into the long brass tube. The galvanometer is inspected again. The extent to which the galvanometer has changed from zero indicates the extent to which the gas has absorbed the radiant heat from the right-hand heat source and blocked this heat from radiating to the thermopile through the tube. If a highly polished metal disc is placed in the space between the thermopile and the brass tube it will completely block the radiant heat coming out of the tube from reaching the thermopile, thereby deflecting the galvanometer by the maximum extent possible with respect to blockage in the tube. Thus the system has minimum and maximum readings available, and can express other readings in percentage terms.

Information and images of this month's Did You Know? are from http://en.wikipedia.org

Links of Interest on the Web

Useful URLs

Bat Conservation International: http://www.batcon.org BCI, based in Austin, Texas, is devoted to conservation, education, and research to protect bats and their ecosystems around the world.

DoD Legacy Resource Management Program: https://www.dodlegacy.org DoD program that provides funding to natural and cultural resource projects that have regional, national, and/or multi-Service benefits. The Legacy Tracker lets you download fact sheets and reports for completed Legacy funded projects.

DoD TER-S Document Repository: http://www.nbii.gov/portal/community/Communities/Ecological_Topics/Threatened_&_Endangered_Species/DoD_TES_Document_Repository/ A compilation of DoD Threatened and Endangered Species documents and data made available online through National Biological Information Infrastructure. The information contained within these documents is considered "gray" literature (i.e., not peer reviewed).

Biodiversity Handbook: http://www.dodbiodiversity.org On this website you will find a thorough introduction to biodiversity and how it applies to the military mission; the scientific, legal, policy, and natural resources management contexts for biodiversity conservation on DoD lands; and practical advice from DoD natural resources managers through 17 case studies. A Commander's Guide to conserving biodiversity on military lands is also available.

DoD Partners in Flight: http://www.dodpif.org The DoD PIF Program supports and enhances the military mission while it works to develop cooperative projects to ensure a focused and coordinated approach for the conservation of resident and migratory birds and their habitats.

DoD Pollinator Workshop: http://www.DoDpollinators.org Provides an overview of pollinators and the reasons they are important to DoD. This website highlights the 2009 NMFWA workshop on pollinators, and has many useful resources including factsheets and technical reports, pocket guides to identifying pollinators, and links to other websites on pollinators.

DoD Invasive Species Outreach Toolkit: http://www.DoDinvasives.org In order to help installation natural resources managers protect the natural resources on our nation's military lands, the Legacy Program developed the Invasive Species Outreach Toolkit. The Toolkit is an education and outreach tool to help DoD land managers communicate about invasive species. It contains modifiable outreach materials such as posters, brochures, reference cards, and a PowerPoint presentation. A list of resources to help identify information and funding sources is also included.

DENIX: https://www.denix.osd.mil DENIX is an electronic environmental bulletin board that provides access to environmental information, such as Executive Orders, policies, guidance, INRMPs, fact sheets, and reports. This website is under reconstruction. We will advise you when it is fully operational. In the meantime, we suggest you visit these other Natural Resources Links.

Cooperative Ecosystem Studies Unit Network (CESU): http://www.cesu.psu.edu/ This network of 17 cooperative units provides research, technical assistance, and training to federal resource and environmental managers. DoD is a member of 12 units of the CESUs National Network.

DISDI Portal: https://rsgis.crrel.usace.army.mil/disdicac (DoD only, CAC required) The DISDI Portal offers high-level geospatial data on DoD's installations, providing strategic maps of installations and information on how to access more detailed data. IVT data forms the foundation for the DISDI Portal, which is accessible to DoD staff with a common access card.

PARC - Partners in Amphibian and Reptile Conservation: http://www.parcplace.org/ Partners in Amphibian and Reptile Conservation (PARC) is an inclusive partnership of individuals and entities dedicated to the conservation of amphibians and reptiles (i.e., herpetofauna) and their habitats as integral parts of our ecosystem and culture through proactive and coordinated public/private partnerships.

Strategic Environmental Research and Development Program (SERDP): http://www.serdp.org/ SERDP identifies, develops, and transitions environmental technologies that relate directly to defense mission accomplishment.

Environmental Security Technology Certification Program (ESTCP): http://www.estcp.org/ A DoD program that promotes innovative, cost-effective environmental technologies through demonstration and validation at DoD sites.

Contact Us

Who we are and where to find us!

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For additional information about DoD's Natural Resources, please contact the Deputy Director, Natural Resources or the DoD Natural Resources Conservation Staff.