



# Fort Collins Science Center Fiscal Year 2007 Science Accomplishments



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# USGS Fort Collins Science Center Fiscal Year 2007 Science Accomplishments

By Juliette T. Wilson, Ed.<sup>1</sup>

## Science for Resource Management

In Fiscal Year 2007 (FY07), the U.S. Geological Survey (USGS) Fort Collins Science Center (FORT) continued research vital to U.S. Department of the Interior science and management needs and associated USGS programmatic goals. FORT work also supported the science needs of other government agencies as well as private cooperators. Specifically, FORT scientific research and technical assistance focused on client and partner needs and goals in the areas of biological information management, fisheries and aquatic systems, invasive species, status and trends of biological resources, terrestrial ecosystems, and wildlife resources. In addition, FORT's 5-year strategic plan was refined to incorporate focus areas identified in the USGS strategic science plan, including ecosystem-landscape analysis, global climate change, and energy and mineral resource development. As a consequence, several science projects initiated in FY07 were either entirely new research directions or amplifications of existing work.



**Field technician with boreal toad in Rocky Mountain National Park. Photo by Erin Muths, USGS.**

Highlights of FORT project accomplishments are described below

under the USGS science program with which each task is most closely associated. The work of FORT's 6 branches (Aquatic Systems and Technology Applications, Ecosystem Dynamics, Information Science, Invasive Species Science, Policy Analysis and Science Assistance, and Species and Habitats of Federal Interest) often involves major partnerships with other agencies or cooperation with other USGS disciplines (Geology, Geography, Water Resources) and the Geospatial Information Office. These are noted using the following symbols:



= *major collaborative venture,*



= *integrated science projects involving other USGS disciplines.*

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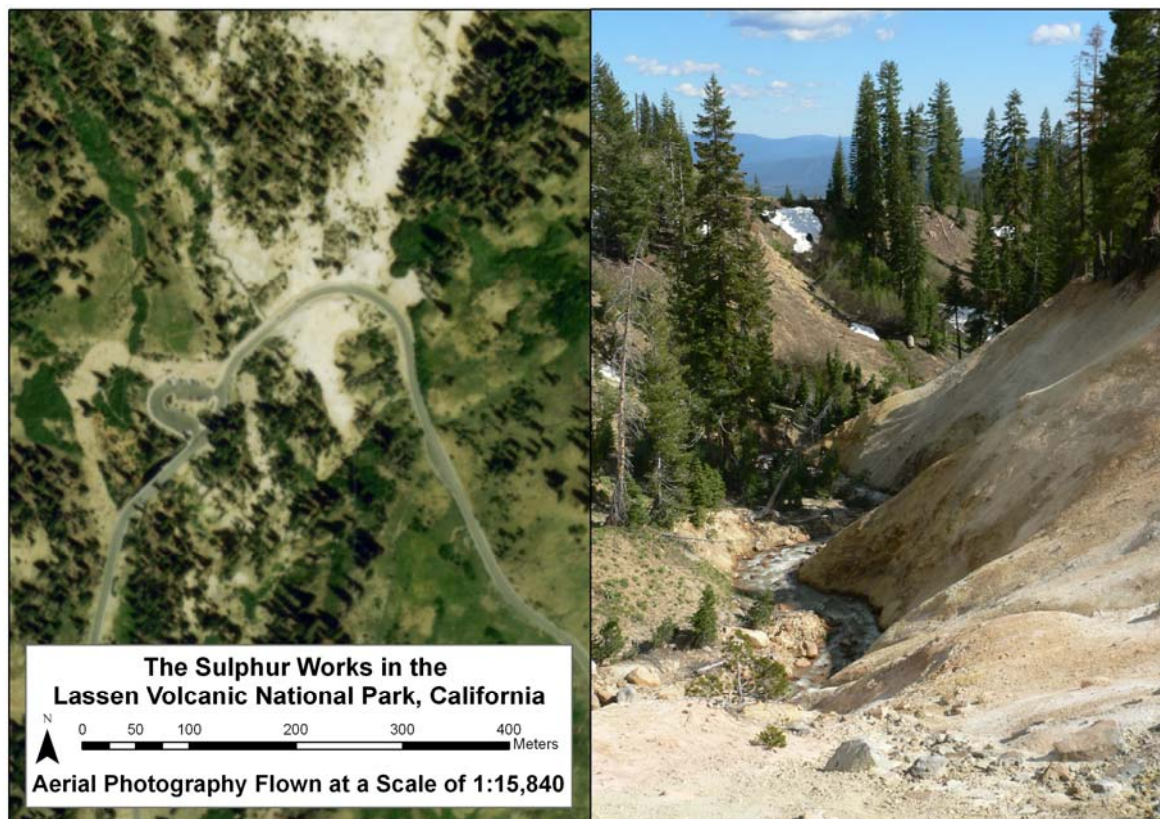
<sup>1</sup> ASRC Management Services, under contract to the USGS Fort Collins Science Center, 2150 Centre Avenue, Bldg. C, Fort Collins, CO 80526-8118.

## Biological Informatics

*Science activities in this category support implementation of technologies and tools to integrate, analyze, visualize, and apply biological information to natural resource issues and provide research that supports the advancement of biological informatics capabilities.*



**Comparative Vegetation Mapping for Lassen Volcanic National Park.** The USGS-National Park Service Vegetation Mapping Program (USGS-NPS VMP) partnership is in the process of developing vegetation cover maps for most units in the National Park system. New methodologies are needed to increase the speed and accuracy of vegetation mapping, reduce the cost, and produce a quantitatively based vegetation database. Working in Lassen Volcanic National Park, FORT staff are comparing the widely used, traditional aerial photo-interpretation methodology with the relatively new Discrete Classification Mapping (DCM) methodology. DCM could be a more accurate and efficient mapping methodology that the USGS-NPS VMP will want to consider for mapping other medium- to large-sized parks. This comparative study is a collaborative effort involving FORT, USGS-NPS VMP, Lassen Volcanic National Park, the Klamath Network, engineering-environmental Management, Inc. (e2M), and Geographic Resource Solutions (GRS). The photo-interpretation is being performed by e2M, FORT is automating the photo-interpreted data into a GIS, and GRS is applying the DCM methodology. FORT personnel will conduct a comparison of the two resulting GIS datasets. In FY07, FORT coordinated and facilitated the completion of the vegetation classification based on FY06 field data collected by



Aerial photography for the Lassen Volcanic National Park was flown at a scale of 1:15,840. The Sulphur Works is shown in an aerial view on the left. On the right is a view at the Sulphur Works looking south from near the bend in the road. Photos courtesy of Bob Waltermire. USGS.



GRS. e2M completed the photo-interpretation of the aerial photographs for the park and the buffer zone around the park. FORT is in the process of converting the interpreted overlays to the vector GIS format. The overall project will be completed in FY09.



**Web Applications for Natural Resource Information Management.** Technical assistance, especially Web application and Web site development, continues to be a growing need in Department of the Interior (DOI) bureaus. Over the years, FORT's Web Applications Team has provided technical support, applications development, and training for a range of projects for the U.S. Fish and Wildlife Service (FWS). In particular, FORT enhances and supports the Environmental Conservation Online System (ECOS), a Web-based suite of applications developed by FORT specialists that provides scientific support and data management to the FWS. Managers and field office staff use these applications to record and track activities and expenditures and to develop accomplishment reports in critical resource management areas, such as those involving fish habitat, contaminants, and threatened and endangered species. FORT's FY07 accomplishments include augmenting data input and the reporting functionality of the different ECOS applications and creating a prototype of the Information, Planning, and Consultation System (IPaC). IPaC will streamline impact analyses the FWS conducts on development activities that could affect threatened and endangered species.

## Enterprise Information

*This work involves creating elements of the USGS integrated information environment.*



**myUSGS Infrastructure Development.** The USGS Geospatial Information Office (GIO) is leading an effort to create the next-generation USGS Web-based toolkit as a foundation for the integrated information environment that supports science and decision making. This task focuses on development of a centralized suite of applications and servers designed to make collaboration within a science community and deployment of a community-specific application faster and easier. The adoption of open standards for guiding application development and information interoperability means that software developers working with scientists will have a defined, supported, and secure platform to deploy high-end, project-specific applications. FORT staff are developing the project's core tools, including forums, document and content management tools, data repositories and document libraries, and community-specific wikis (sites that allow users to easily create, edit, and link Web pages) and blogs, as well as designing the overall infrastructure. In FY07, FORT staff worked with the Central Region GIO to deploy V2.0 of myUSGS, the base application that encapsulates these collaboration and deployment tools.

## Fisheries: Aquatic and Endangered Resources

*Activities related to fish and aquatic resources involve research and technical assistance that promote understanding of functional relationships among aquatic species and habitats to conserve or restore community structure and function—especially for at-risk species. Products include research and technology tools that support problem solving, decision making, and development and evaluation of adaptive management strategies for restoration and maintenance of aquatic resources.*



**Developing Native Fish Sanctuaries in the Lower Colorado River Basin.** Bonytail and razorback suckers are endangered fish species that inhabit the Colorado River. Recovery programs typically have focused on predator removal and stocking native fish in the mainstem river. More recently, emphasis has been on development of spatially isolated habitats to serve as native fish sanctuaries dedicated to native fish production under natural conditions, as recommended in the conservation plan for native fish of the lower Colorado River basin. This study involved working with partners to develop and manage native fish sanctuaries at 5 sites. In FY07, FORT biologists and partners renovated Parker Dam Pond, stocked bonytail, and documented reproduction. They documented reproduction for both species at Davis Cove, installed solar aerators at Three-Finger Lake, replaced the aerator at Mohave Community College Pond, and drafted management plans for 4 sanctuaries. A forthcoming USGS Open-File Report details these activities. Parker Dam Pond is the first sanctuary in the Colorado River basin established specifically for bonytail. Both this site and Davis Cove have been very successful in a short time. Partners include the U.S. Bureau of Reclamation (BOR), FWS, U.S. Bureau of Land Management (BLM), National Park Service (NPS), Arizona Game and Fish Department, California Department of Fish and Game, and Arizona State University.



**Developing a Monitoring Program for Native Fish Sanctuaries in the Lower Colorado River Basin.** To assist managers in evaluating the effectiveness of various fish sanctuary management strategies, FORT scientists developed monitoring programs to (1) indicate which factors are important for cost-effective native fish production in these sanctuaries and (2) evaluate management activities presumed to enhance sanctuary function. In FY07, detailed monitoring was accomplished at 7 sites, 5 of which support native fish. Monitoring included water quality (e.g., temperature, chlorophyll, zooplankton, nutrients, metals); fish condition, reproduction, and recruitment; depth measurement; and aquatic vegetation mapping. Monitoring indicated reproduction at 2 sites. When it was determined that one site had low oxygen, aerators were installed. When Davis Cove showed high salinity, researchers developed a pump test and



**Members of the Native Fish Work Group harvesting the endangered razorback sucker from rearing ponds at Bubbling Ponds Hatchery near Cornville, Arizona. These fish are stocked in the Colorado River and sanctuary ponds to augment or establish wild communities. Photo courtesy of the U.S. Bureau of Reclamation.**



determined that salinity can be lowered mechanically. Because managers need to remove large fish without stressing other sizes, the research team evaluated the efficiency of using trammel nets with mesh sizes designed for collecting only large fish. Partners include the BOR, FWS, BLM, NPS, Arizona Game and Fish Department, and California Department of Fish and Game.

**Hydroecological Integrity Assessment Process.** State and Federal agencies that deal with water management and natural resources have regulatory and management objectives to manage flow alteration yet maintain stream integrity. The FORT-developed Hydroecological Integrity Process (HIP) is designed to address this objective. HIP was applied to streams in the states of Missouri and Texas during FY07. A total of 171 indices were used to classify streams in Missouri (using records from 148 gaging stations) and Texas (297 gaging stations). As part of the HIP work, both the Hydrologic Assessment Tool and Stream Classification Tool were developed for both states. Process and software refinements have occurred with each new application; for example, a flow/response component has been added to HIP, while state-specific index plots were added to the software. Software training was provided to one Federal and two State agencies in Missouri and four State agencies in Texas.

**Investigations on Environmental and Biotic Parameters and Their Impact on Optimizing Treatment Wetlands in the Western United States.** Loss of critical wetland and riparian habitat due to depletion of already scarce water resources for municipal and agricultural development is an increasingly severe problem, impacting biodiversity in the arid western United States. Often the only water available for maintaining, restoring, or creating wetland and riparian habitat is water of impaired quality. Constructed wetlands can serve as water treatment alternatives that are relatively low-cost, low-maintenance, environmentally friendly, and habitat-enhancing. Client-oriented investigations emphasize (1) evaluating constructed (engineered) wetlands technology throughout the arid West and (2) publishing findings to help interested parties apply this technology to other areas regionally, nationally, and globally. Two articles to be published later in 2008 describe plant decomposition investigations performed at the San Jacinto/Hemet Demonstration Treatment Wetland in San Jacinto, Calif. The papers coupled FORT research findings with practical operations and maintenance advice for operators of treatment wetlands. Specific recommendations for seasonal timing, duration, and magnitude of water-level fluctuations that would enhance the invertebrate community and improve plant decomposition rates include lowering spring water levels to enhance emergent plant growth, increasing water levels during the fall-winter period, and inundating detritus mats in the winter.



**Developing a Web-based Identification Guide and Ecological Resource for Diatoms.**

Diatoms are accepted, robust indicators for monitoring and assessing freshwater ecosystems in western North America (e.g., the Environmental Protection Agency [EPA] Environmental Monitoring and Assessment Program [EMAP], and the USGS National Water Quality Assessment), but their full potential has been hindered by inconsistencies and sparse information on ecological tolerances. As a result, existing taxonomic resources are incomplete. To assist States, Tribes, and other public organizations in using diatom data collected from western North America, the EPA—through the regional EMAP program—has funded the development of a Web resource that integrates taxonomic and ecological diatom data. FORT and partner scientists are using existing permanent diatom slides prepared for the Western EMAP to develop the site content. This Web resource will provide a tool that promotes internally consistent and publicly accessible taxonomic data. Basic taxonomic and life history research will be compiled for a variety of taxa and presented in a format that highlights each species on its own individual Web page. A

collaborative team from the USGS, EPA, University of Colorado, and Academy of Natural Sciences of Philadelphia developed prototypes for the project (available at <http://instaar.colorado.edu/diatoms/>). Following feedback from the Project Review Board, the team began the process of populating the database.

**Modeling of Fish Habitat under Ice Cover.** The U.S. Department of Agriculture (USDA) Forest Service is preparing an Environmental Impact Statement (EIS) evaluating conditions to be placed on a special-use permit for Long Draw Reservoir on a tributary to the Cache la Poudre River in northern Colorado. A portion of the mitigation plan for the reservoir involves winter flow releases to the Poudre River. FORT staff obtained a hydrodynamic model that can simulate flow conditions under ice and applied it to an existing study area to obtain depth and velocity conditions for the winter flows being considered in the EIS. The hydrodynamic results were used to characterize habitat for trout under ice cover. In winter, the study site has a few deep pools connected by long sections with high velocities. Increasing winter flow tends to increase the area of the pools and thus increase winter habitat; however, velocities in the ice-constricted sections between pools also increase. Managers can use the results to identify trade-offs between the costs of maintaining winter flows and the habitat thus obtained. Study results were published in *Simulation of Flow and Habitat Conditions under Ice, Cache la Poudre River—January 2006, USGS Open-file Report 2007-1282*.

## Invasive Species

*Research on invasive species involves (1) collection, synthesis, and provision of invasive species information; (2) early detection and rapid assessment of new invaders or incipient populations; (3) monitoring and forecasting changes in populations and distributions of established invaders; (4) developing and testing prevention, control, and management strategies; and (5) determining invasive species impacts and habitat susceptibility to invasion.*

**Modeling Capture Probability of the Invasive Brown Treesnake.** The brown treesnake is a highly adaptable, invasive species that has extirpated most native bird, bat, and lizard species on Guam since its inadvertent introduction to the island in the 1950s. Visual searching is one



**Brown treesnake detector dog team and rapid response team in training on Guam. USGS photo.**

technique currently used to detect and control brown treesnakes, especially incipient (emerging) populations. The cost of an eradication program depends upon the least capturable individual. Heterogeneity in visual detection probabilities (through analysis of capture variability) sets the cost for control efforts, particularly control programs directed at eradicating an incipient or nearly extirpated population. To facilitate the development and refinement of detection and control technologies, biologists in this study identified and quantified the factors that affect visual detection of brown treesnakes. FORT scientists are modeling detection probabilities as a function of

individual covariates (size, sex, condition, prior capture history, etc.) and latent (unexplained) heterogeneity. Improving our understanding of factors affecting heterogeneity not only will refine our ability to strategically plan eradications, but also will improve the precision of abundance estimates. New data also allow comparisons between snake numbers estimated through visual searches versus trapping to determine their relative efficacy for guiding management plans.



**Saipan Initiative 2007.** Brown treesnakes are largely responsible for the loss of most native bird and lizard species on the island of Guam. These snakes have shown that they can survive air and shipping transport from Guam, placing the entire Pacific region at risk of invasion. The USGS Brown Treesnake Rapid Response Team (RRT), funded by the U.S. Department of the Interior, provides a multiagency network of personnel trained to respond to brown treesnake sightings on snake-free islands. The island of Saipan is at high risk of invasion due to its proximity to Guam and the large volume of air and sea craft arriving from Guam. Since the mid 1980s, there have been numerous brown treesnake sightings on Saipan. In 2005, the RRT detected a cluster of sightings near the Saipan airport, but attempts to confirm a possible snake population there were haphazard, geographically restricted, and insufficient for developing strong conclusions. In early 2007 the RRT, in cooperation with the Commonwealth of Northern Marianas Islands Department of Lands and Natural Resources, conducted extensive and intensive searching throughout that vicinity. Additional participating agencies included the Guam Division of Aquatic and Wildlife Resources, the U.S. Department of Agriculture's Wildlife Services, and Hawaii State agencies. GIS tools were used to determine focal search areas for this effort. Search efforts were supported by extensive visual detection, trapping, and canine teams, each guided by information resulting from the last two decades of USGS brown treesnake research. More than 1500 hours of visual searches were conducted along more than 300 linear km of forest edge and interior. Over the 21 days of this intensive search, as many as 49 searchers were involved simultaneously. Fortunately, no snakes were detected in the focal areas. The failure to find snakes despite a precisely focused and intensive search effort increases confidence that an incipient population does not reside in the search area.



**Control of Invasive Burmese Pythons in Florida.** Invasive Burmese pythons have become established in the greater Everglades ecosystem, and are expanding their range in south Florida. These giant (up to 20 ft and 250 lbs) snakes are efficient predators of warm-blooded species—ranging in size and content from wrens to deer—and represent a novel threat to which native species are poorly adapted. In FY07, FORT scientists with expertise in control of invasive brown treesnakes were asked by cooperating agencies to initiate a major new science project focused on developing techniques for detecting, capturing, and controlling populations of giant constricting snakes in Florida and elsewhere. Investigators



**This Burmese python was found along the Shark Valley scenic loop road within Everglades National Park. Photo by Bob DeGross, NPS.**



have begun developing and evaluating capture tools for areas with high densities of pythons outside Everglades National Park. Results will be applied to detecting and capturing pythons as they invade Key Largo to support conservation efforts for federally endangered small mammals there. FORT scientists also are conducting a risk assessment of invasion potential among several giant constrictor species for use in formulating policy to prevent further invasions. Cooperating agencies include the Endangered Species and National Wildlife Refuges branches of the FWS, NPS, South Florida Water Management District, Florida Department of Environmental Protection, and University of Florida.



**Expanding the Volunteer Network for Weed Data Collection on Refuges.** The U.S. Fish and Wildlife Service needs statistically sound, cost-efficient surveys of invasive plants and animals on more than 500 National Wildlife Refuges (NWRs) across the U.S. In cooperation with the FWS, FORT scientists and colleagues with the National Institute of Invasive Species Science are greatly expanding the volunteer network and weed-mapping capabilities. Scientists developed sampling protocols, trained refuge staff, and advised volunteers from the local community. In this third year of cooperation, researchers collaborated with volunteers from the Friends of the National Wildlife Refuge System to map non-native plant species at Humboldt Bay, Great Meadows, and Minnesota Valley NWRs. Data from all refuges involved in this Volunteer Invasive Species Mapping Project is continually uploaded to the National Institute of Invasive Species Science (NIISS) Web site ([www.NIISS.org](http://www.NIISS.org)) where it can be accessed by local, regional, and national managers. Staff visited the Hakalau NWR in Hawaii and tested new forecasting-based “smart surveys” in San Pablo Bay NWR (Calif.), Trempealeau NWR (Wisc.), and Florida Keys NWRs. Creating networks of trained volunteers for invasive species surveys is the first step in creating a cost-efficient early detection and rapid assessment program in the National Wildlife Refuge System.

**Expanding the Web-based System for Sharing Data on Invasive Species.** Data sharing remains the most critical need for managing harmful non-native plants, animals, and pathogens. In response to this need, FORT scientists and partners at Colorado State University developed the Global Organism and Detection Monitoring system. In FY07, researchers greatly expanded the capabilities and baseline datasets (including some collected by other USGS researchers) to better create watch lists, an early warning/rapid-assessment system, and predictive models of harmful invasive species. Sensitive data (private lands or the locations of biological control agents) can be restricted (see *Balancing data sharing requirements for analyses with data sensitivity*, *Biological Invasions* 9:597–599). New online mapping allows users to download color maps of potentially suitable habitat and known presence locations of particular species for containment and control. The system architecture, methods, and capabilities have been presented in the peer-reviewed literature (*A global organism detection and monitoring system for non-native species*, *Ecological Informatics* 2:177–183). This is the first system of its kind and capability (see [www.NIISS.org](http://www.NIISS.org)).

**Developing Standardized Methods for Surveying and Monitoring Invasive Plant Species.**

Surveys and monitoring of harmful invasive plant species must be statistically sound and accurate in terms of taxonomy, abundance, and geographic location. A new textbook, *Measuring Plant Diversity: Lessons from the Field* (2007, *Oxford University Press*), is the first quantitative methods book to be published on this topic in more than 30 years. The book details the history, theory, and earlier problematic techniques for measuring plant diversity, then provides details and examples of improved multiscale, multiphase, and nested-intensity approaches developed and tested over the past 10 years. Several detailed case studies are used to help plant ecologists, landscape ecologists,

resource managers, and graduate students design or modify techniques to accurately quantify the effects of grazing, fire, climate change, land-use change, invasive species, or other perturbations in natural areas. In addition, a companion paper, *The art and science of weed mapping* (Environmental Monitoring and Assessment 132 [1-3]:235–252) provides Federal and State agencies, Tribes, and nongovernmental organizations with simple and accurate field and modeling approaches for evaluating the abundance and distribution of invasive plant species.

### **Advanced Modeling Solution**

**Center.** Surveys and monitoring for harmful invasive species are always incomplete, partly because the species keep spreading to new areas.

Researchers and resource managers alike require predictive modeling capabilities to determine the potential distribution of invasive species.

Numerous techniques are available, each with their own peculiarities and requirements. Additionally, out-of-the-box solutions do not always work for different taxa at various spatial extents and resolutions. FORT has established an “Invasive Species Advanced Modeling Room” where scientists are exploring the latest in predictive modeling techniques, including which techniques work better with different datasets, taxa, and spatial extents and resolutions.

These capabilities are being extended to other Federal researchers working with invasive species, such as Asian Carp (USGS Upper Midwest Environmental Sciences Center), nutria (USGS National Wetlands Research Center), sudden oak death (USDA Forest Service), and pythons and brown treesnakes (FORT). The solutions room will provide access to modeling capabilities and learning opportunities for researchers. The room, which accommodates individuals or small groups of researchers, includes a high-performance GIS computer connected to a smartboard for interactive learning.

**Restoring Native Riparian Vegetation in the Context of Invasive Species Control.** Long-term, sustainable control of invasive plant species largely depends upon successful site revegetation after removing or controlling the invasive, yet revegetation in the context of controlling invasives receives relatively little attention. Current information has not been well synthesized, and site-specific studies often have not been conducted with methodologies that enable rigorous interpretation of results. This project is designed to improve the overall understanding of the invasive plant tamarisk (saltcedar) and test native plant revegetation methods. In FY07, FORT scientists completed greenhouse experiments on the salinity tolerance of candidate species for revegetating xeric sites, completed field studies of xeric riparian reference sites along the Rio Grande and other rivers in New Mexico, compiled/edited peer-reviewed papers on restoration in the context of tamarisk removal for a special section of *Restoration Ecology* (for the March 2008



**The Invasive Species Advanced Modeling Room at the Fort Collins Science Center, which provides access to modeling capabilities by means of a high-performance GIS computer connected to a smartboard (shown here) for interactive learning. Photo courtesy of Tom Stohlgren, USGS.**



issue), and monitored the effects of managed streamflow on the relative abundance of native woody plants (for example, cottonwood and willow) and tamarisk along the Bill Williams River, Ariz. (see Defining ecosystem flow requirements for the Bill Williams River, Arizona, *Open-File Report 2006-1314*). Information and methods developed through this project will improve restoration of native habitats at national wildlife refuges and other sites. Project collaborators include the NPS, FWS, and Utah State University.

**Effects of Wildfire on Non-native Plants in Conifer Forests of the Western United States.** Fire is a natural part of most forest ecosystems in the western United States, but its effects on nonnative plant invasion have been studied only recently. Also, forest managers are engaging in fuel-reduction projects to lessen fire severity, often without considering potential negative ecological consequences, such as nonnative plant species introductions. Graduate students and researchers at FORT and the USGS Northern Rocky Mountain Science Center cooperated to evaluate effects of wildfires at 7 sites in coniferous forests in the western United States. Wildfire was responsible for both significant increases in nonnative species richness and cover and a significant decrease in native plant species cover. Mechanical thinning and prescribed-fire fuel treatments were associated with significant changes in plant species composition at some sites. Variables related to increased levels of invasive plants included fire severity, soil nutrients, and elevation. Early assessments of post-fire stand conditions can guide rapid responses to nonnative plant invasions.

## Status and Trends of Biological Resources

*Status and trends research identifies ongoing or impending changes to species, habitats, and ecosystems. Key goals include developing and evaluating inventory and monitoring protocols, analytic tools, and other technologies to measure biological status and trends; collecting, archiving, and sharing critical, high-quality monitoring data in cooperation with partners; and providing analyses and reports that synthesize this information for the scientific community, resource managers, policy makers, and the public.*

**Assessing the Use of Geospatial Data Post-Katrina and Rita.** Geospatial data were crucial components of the response and recovery efforts after Hurricanes Katrina and Rita. Although many individuals and organizations provided and used these data, little is understood about the effectiveness and efficiency of their delivery and use. Social scientists at FORT worked with another USGS science center to conduct research on how geospatial data were used after these hurricanes. The scientists conducted more than 50 interviews of data providers and users and developed a protocol for analysis of interview transcripts. Final analysis is in progress. Although many studies have been conducted to better understand the lessons of the hurricanes, this task involved in-depth interviews of a broad range of geospatial data users and providers. Preliminary analyses indicate that these data are rich sources of information that can be used to improve the delivery and use of geospatial data in the aftermath of disaster events.



### **Integrating Agriculture and Conservation.**

FORT assistance to the USDA Farm Service Agency (FSA) remains focused on refining management of lands enrolled in the Conservation Reserve Program (CRP) and other USDA-administered conservation programs. Collaborating with the Kansas Department of Wildlife and Parks, field data collection was completed in FY07 for a 2-year study to determine effects of incidental cattle grazing on linear conservation practices associated with winter grazing in fields of crop stubble. In cooperation with the USDA Natural Resources Conservation Service, Colorado State University, and a private landowner, FORT scientists continued an investigation on grazing practices to refine management of CRP grassland in the shortgrass steppe. In cooperation with the FSA, FWS, Iowa Department of Natural Resources, and Iowa Department of Agriculture and Land Stewardship, researchers also investigated the environmental benefits of Conservation Reserve Enhancement Program (CREP) wetlands in Iowa. This long-term study collaboration will model potential nitrogen reduction, hydrological storage, responses of wildlife species other than migratory birds and assess vegetation communities in existing Iowa CREP projects. Results will indicate whether conservation policies and viable economic uses are complementary on agricultural lands. Such long-term studies as these help refine agricultural conservation policies and make them more beneficial to both agricultural operations and wildlife species endemic to shortgrass ecosystems.

**Migratory Bird Response to Agricultural Practices.** This task involves forecasting the effects of agricultural practices on prairie wetlands and determining implications for the conservation of migratory shorebirds. FORT scientists, in collaboration with the FWS and Colorado State University, have initiated development of dynamic conceptual and mathematical models to elucidate how agriculturally driven environmental change and global climate change will modify conditions and habitats for breeding, en route, and wintering bird species across prairie wetland landscapes in the coming decades. The remaining native prairies and wetlands in midcontinental North America are highly vulnerable to agricultural policies and practices, land conversion, hydrology alteration, and water pollution. Understanding the relations among bird populations, agricultural practices, and changing climate is necessary for protecting migratory bird species, and many agencies within the Departments of Agriculture and the Interior are charged with developing this understanding. In FY07, FORT scientists conducted extensive searches and syntheses of the scientific literature on agricultural practices, contaminants, sedimentation, wetland form and function, the mitigating effects of buffers, global climate change, shorebirds, invertebrates, and human dimensions. A bibliographic database identifying nearly 500 sources pertinent to the project has been assembled, and 300 of these citations have been obtained and reviewed. The pertinent information has been summarized and portrayed in diagrammatic form as a conceptual model in



**A USGS rangeland specialist and Kansas Dept. of Wildlife and Parks wildlife research biologist build cattle enclosures in grassed terraces in Ness County, Kans. Researchers assessed the potential impacts of incidental grazing on grassed waterways, grassed terraces, and crosswind trap strips established under the CRP. Photo by Art Allen, USGS.**



**Flooded crop fields, like this one in North Dakota, provide temporary respite for migratory shorebirds. Photo by Susan Skagen, USGS.**

preparation for extensive review by subject experts and wetland and wildlife managers. Plans are underway to conduct field work designed to develop selected features of the model—including shorebird, landscape, and habitat relations—that ultimately will inform shorebird conservation. A manuscript addressing the demography of shortgrass prairie birds relative to prairie fragmentation was completed; this paper culminates 7 years of field work and includes the final analyses of nest survival of more than 1,200 grassland bird nests and density estimates from more than 70 bird

surveys (over 600 point counts). The conceptual and mathematical models will serve the conservation planning process in many ways, not only in clarifying the roles and relative importance of a myriad of factors, but also serving as catalysts for further discussion and as tools for educating managers, landowners, and scientists.

**A Diagnostic Tool for Choosing Appropriate Socioeconomic Analyses for National Wildlife Refuges.** Staff with U.S. Fish and Wildlife Service refuges, planning offices, and visitor services need a way to consistently assess the socioeconomic values of refuge benefits (attributes). In addition, they must be able to determine the specific attributes and associated level of analysis needed for the refuge Comprehensive Conservation Plan (CCP) planning process. FORT has initiated development of a diagnostic tool to determine the appropriate scope and scale of the socioeconomic analysis needed for a particular refuge's CCP and provide documentation on how the level of analysis was chosen. The tool will be a decision support system (DSS) for (1) conceptualizing, quantifying, and valuing the complete suite of attributes provided by a refuge; (2) prioritizing the specific services that need to be addressed in the CCP planning process; (3) identifying the most appropriate socioeconomic tools for the CCP assessment; and (4) modifying these assessment tools within the reality of budget and planning timeframe constraints. In FY07, planning office staff in two FWS Regions and in three refuges tested a prototype economic DSS. Initial feedback from the planners and refuge managers has been extremely positive. Although FORT economists had originally envisioned developing the tool to help determine scope and scale needed for a particular refuge, the initial testing has shown support for using the tool in many cases as a way to assess appropriate methods and levels of analysis across all FWS refuges. Work in FY08 includes developing the social component and a Web-based demonstration model, then refining and testing it with more FWS planners and refuge managers across all regions. The DSS will give managers the ability to develop a socioeconomic assessment plan that is custom-tailored to their refuge.

### **Socioeconomic Considerations for Public Lands Management and Planning.**

DOI and other public land managers require clear and objective guidance on the use of socioeconomic information in their land management and planning. Many agencies are required by law to develop a plan for each unit or complex of public land (e.g., refuge CCPs, BLM resource management plans). These plans generally must contain an analysis of social and economic conditions and evaluate social and economic results from likely management scenarios. Moreover, public land managers, planners, and policy makers are generally responsible for including social and economic



**Kayakers on Lake Umbagog, N.H. FWS photo.**

assessments in the long-term plan in such a way that understanding these factors aids planning decisions and helps guide management actions. Providing a better understanding of these social and economic considerations in planning is the goal of this task. FORT social scientists have worked with the FWS refuge system and the BLM to provide social and economic assessments in support of their long-term planning. Recently they have begun working closely with the BLM to provide input on planning efforts for their Resource Management Areas and the socioeconomic considerations surrounding planning in oil and gas development. FORT researchers also continue to provide assistance with CCP development for FWS refuges in the Pacific, Southwest, Northeast, and Mountain-Prairie regions. Research involves social analyses of public attitudes related to specific refuges and their management; regional economic impact analyses of current and proposed management activities; nonmarket valuation of refuge visitor benefits; and stakeholder assessments to identify and classify (1) the primary policies, regulations, and stakeholders affecting the refuge's CCP and (2) obstacles and opportunities affecting the planning process. Accomplishments in FY07 for both agencies include the following:

- ***Socioeconomic Analysis for Lake Umbagog National Wildlife Refuge:*** The FWS released the draft environmental impact statement for the refuge's CCP that incorporated information from the stakeholder survey and economic impact analysis conducted by FORT to address socioeconomic impacts in the CCP.
- ***Socioeconomic Analysis for Prime Hook National Wildlife Refuge:*** A final report from a survey of refuge visitors and community residents was completed and presented to the FWS. Refuge planners and managers will use the survey results as they begin developing public-use alternatives for their CCP. The economic impact analysis will be completed after management alternatives are developed by the FWS in FY08.
- ***Socioeconomic Analysis for Rappahannock River Valley National Wildlife Refuge:*** A report of the community survey results for this refuge was finalized and presented to the FWS, and an economic impact analysis of the draft CCP management alternatives also was completed. Refuge planners and managers are using survey and economic impact results to develop conceptual alternatives for their draft CCP.



- ***Stakeholder Assessment of Canaan Valley National Wildlife Refuge:*** FORT scientists conducted an in-depth stakeholder assessment to better understand contentious community issues as well as common ground that may exist. The economic impact analysis will be completed after management alternatives are developed by FWS in FY08. Refuge and planning staff will use this information to inform alternatives that will be developed for the CCP. Additionally, this information will enrich their traditional public process by providing them with a better understanding of a diverse set of stakeholders.
- ***Socioeconomic Analysis for Moosehorn National Wildlife Refuge:*** FORT staff met with refuge staff to identify and discuss the socioeconomic issues that need to be addressed in their upcoming CCP. The main issue is a campground operated by the State of Maine on refuge land that has about 24,000 visitors each year, but has been determined to be an incompatible use by FWS guidelines. Other issues include expanding the land acquisition boundary, increasing wilderness acreage, timber harvesting, refuge visitation, and impoundments for flood control. FORT social scientists will be working with the refuge staff in FY08 to provide the needed socioeconomic research.
- ***Socioeconomic Analysis for Bureau of Land Management:*** During FY07, FORT began an Intergovernmental Order (IGO) with the BLM to help improve the quality and consistency of socioeconomic analyses in BLM resource management plans and environmental impact statements. FORT social scientists also will support BLM State and field office management activities by providing socioeconomic research, technical assistance, reference materials, and tools.

## Terrestrial, Freshwater, and Marine Ecosystems

Ecosystem investigations aim to quantify and understand factors that influence variation in key ecosystem components over time and space. Emphasis is on developing indices of ecosystem sensitivity to environmental change and vulnerability to potential stressors, and producing tools to predict ecosystem responses to change.



**Adaptation Options of National Parks to Climate Change: U.S. Climate Change Science Program (CCSP) Science and Assessment Product 4.4.** As greenhouse gases continue accumulating in the atmosphere, ecological changes are predicted to range from the emergence of new ecosystems to the disappearance of others. National Park Service resource managers—stewards for some of the few intact ecosystems remaining in the United States—need information and tools for successfully adapting NPS resources and operations to climate change. This project explores climate change processes and stimulates proactive strategies for addressing climate and other environmental changes by broadening the portfolio of management approaches, increasing capacities to learn from management successes and failures, incorporating the multiple scales at which species and processes function, catalyzing ecoregional coordination, valuing human capital, and interpreting the NPS Organic Act in terms of climate change. In FY07, FORT scientists co-authored a CCSP book chapter, *Adaptation Options of National Parks to Climate Change*, and gave invited presentations to (1) the George Wright Society on adaptation options to climate change and (2) Rocky Mountain National Park on expected environmental changes to the park from climate change. Project collaborators include 3 USGS biology centers (FORT, WERC, NRMSC), the USDA Forest Service, the National Center for Ecological Analysis and Synthesis, Emory University, the University of Rhode Island, and The Nature Conservancy.



## Wildlife and Terrestrial Resources

*Science conducted in this area provides a foundation for the conservation of terrestrial plants, wildlife, and habitats by developing the basic biological information that partners need to formulate adaptive management strategies. This work seeks to identify factors that contribute to or limit conservation and recovery efforts for species-at-risk and to provide tools and techniques—such as predictive models, decision support, and expert systems—for science-based management of wildlife populations and their habitats. Further, this research aims to address emerging and future issues of importance to our partners by building additional capabilities, expertise, and capacity.*



**Elk and Bison Grazing Ecology in Great Sand Dunes National Park and Preserve.** In an effort to avoid elk management problems, the newly established Great Sand Dunes National Park is poised to develop an ungulate management plan; however, little is known about the Park's elk herd. To make science-based management decisions, park resource managers need reliable scientific information. FORT scientists continued collecting data on ungulate population size, movements, body condition, and herbivory effects on vegetation communities. These data will be used in ecological models to evaluate ecosystem processes and simulate management scenarios. In FY07, FORT scientists completed the final year of tracking radio-collared elk and bison, collected a second year of winter forage consumption data in vegetation plots, collaborated with USDA Forest Service staff to continue surveys and monitoring of alpine willows, and prepared study sites for the final year of vegetation data collection. The principal investigator was invited to present preliminary results to the NPS Regional Director, the Deer and Elk Workshop, Government Accounting Office visitors to the park, and the Colorado Field Institute (the latter with her co-investigator). Project partners include the NPS, FWS, USDA-FS, BLM, The Nature Conservancy, and the Colorado Division of Wildlife.



**Bison grazing at Great Sand Dunes National Park and Preserve. Photo by Richard Madole, USGS.**

**Aspen Ecology in the Core Elk Range of Rocky Mountain National Park.** A new elk management plan has been developed for Rocky Mountain National Park, with a stated goal of reducing adverse effects of elk herbivory on vegetation. Management actions implemented in response to the plan will attempt to restore the natural range of variability in the elk population and affected plant communities. FORT scientists are designing and implementing a monitoring plan that will help park managers assess the effectiveness of management actions and adapt them when and where necessary to achieve intended goals. In FY07, FORT investigators installed monitoring sites in upland herbaceous and aspen habitats, collected baseline data on consumption of upland herbaceous vegetation, provided input to park personnel on selection of aspen and willow stands to be fenced, and delivered an annual progress report to the park. FORT scientists also demonstrated field methods as part of an informational video for park visitors about the elk management program.

**Declining Beaver Populations in Rocky Mountain National Park.** The beaver is a keystone species whose populations in Rocky Mountain National Park have declined since the 1940s. The goal of this cooperative research with Colorado State University was to understand how beaver influence landscape processes and why their populations have declined and failed to recover. FORT researchers found that beaver are important to wetland ecosystem processes in the park along the upper Colorado River. Beaver dams raised the water table, trapped sediment, and caused water and sediment to be transported to high terraces above the floodplain, in turn creating heterogeneous wetlands. Studies of live-trapped beaver from the eastern side of the Park found no active disease present in their blood, indicating that tularemia (a fatal liver disease) is probably not suppressing beaver populations. Population surveys revealed that active beaver sites were limited to areas that



**Beaver in Rocky Mountain National Park. Photo by Bruce Baker, USGS.**

receive little browsing use by elk. Where beaver and elk use overlapped, beaver selected relatively unbrowsed stems for winter food caches. Intense elk browsing produced willows of low vigor that were small, short, and hedged, with a high percentage of dead stems. Research indicates that when beaver cut tall willows, and intense elk browsing suppresses regrowth, then the interaction of beaver and elk creates severely hedged willows that are unsuitable to beaver but

still provide productive elk forage. Ecological modeling showed that beaver use increases willow productivity if elk are absent, and that beaver and elk competition for willow strongly favors elk over beaver. These findings suggest that beaver evolved in the absence of intense competition with other herbivores. Park personnel are using study results to develop a management plan and EIS evaluating alternatives for elk and vegetation management. The goal is to restore, to the extent possible, the natural range of variability in the elk population and affected plant and animal (including beaver) communities.

**Using Genetic Tools to Obtain Information about the Biology of Summer-Roosting Indiana Bats.** The need for accurate demographic and relatedness information has been identified as a high-priority need for management and recovery of the endangered Indiana bat. At the request of the FWS, scientists from FORT and Indiana State University (ISU) were asked to determine whether this information could be gathered using molecular techniques from noninvasively collected samples, such as fecal pellets. A pilot study has shown that DNA can successfully be extracted from single Indiana bat fecal pellets collected from underneath roost trees. (Successful DNA extraction from fecal pellets of related bat species has been accomplished only once before, in a controlled laboratory setting where several pellets from each bat were pooled for extraction purposes.) Additionally, the scientists have isolated and developed primers for a suite of highly polymorphic microsatellite loci that can be used not only for unique identification of Indiana bats but also for population genetics work and studies of relatedness. It is likely that some of these new markers will work in other closely related bat species. Investigations using these newly developed techniques and primers to gather a variety of data regarding Indiana bats—including information about demographics (population size, survival rates, and individual movements), social structure (relatedness of individuals in roost trees), and population structure—will continue in FY08.



### **Comparison of Trumpeter Swan Populations Using Nuclear and Mitochondrial Genetic Markers.**

For management purposes, the range of naturally occurring trumpeter swans (*Cygnus buccinator*) has been divided into two populations, the Pacific Coast population and the Rocky Mountain population. Little is known about the distribution of genetic variation across the species' range, despite increasing pressure to make difficult management decisions regarding the two populations and flocks within them. To address this issue, FORT geneticists used rapidly evolving genetic markers (mitochondrial DNA sequence and 17 nuclear microsatellite loci) to elucidate the underlying genetic structure of the species. Data from both markers revealed a significant difference between the two populations, with the Yukon Territory as a likely area of overlap. Additionally, they found that both populations have somewhat similar levels of genetic diversity (that of the Pacific Coast population is slightly greater), suggesting that the Pacific Coast birds underwent a population bottleneck similar to a well-documented one in the Rocky Mountain population. Both genetic structure and diversity results reveal that the Tri-State flock, suspected of being a uniquely nonmigratory flock, is not genetically different from the Canadian flock of the Rocky Mountain population and need not be treated as a unique population from a genetic standpoint. Finally, trumpeter swans appear to have much less mitochondrial DNA variability than other waterfowl studied thus far, which may indicate a previous, species-wide bottleneck.



**Trumpeter swan. Photo by Wayne Miller. Used with permission.**



### **Landscape-Scale Modeling to Address Management Priorities for Sagebrush Habitats and Wildlife.**

Since European settlement, sagebrush-steppe ecosystems have undergone dramatic changes—including the effects of recent surges in energy extraction—and have greatly diminished in range. Because past research has focused on fine-scale wildlife-habitat relationships, little is known about the cumulative, landscape-scale effects of habitat loss and intensive energy extraction activities on the viability of sagebrush-obligate wildlife species, such as sage-grouse. To better manage sagebrush landscapes and mitigate effects of land-use changes, the BLM and other land management agencies need spatial datasets characterizing sagebrush habitats and energy-related activities at large spatial scales. Using high-resolution Quickbird and Landsat imagery, FORT and other USGS scientists are developing methodologies to (1) spatially map sagebrush cover and height (by species) and the percent cover of herbaceous plants, bare ground, and litter; and (2) quantify infrastructure developments (e.g., roads, well pads) across large landscapes (in this case, Wyoming). In FY07, Phase 1 pilot field studies and data assimilation were completed, paving the way for Phases 2 and 3: using field data to develop statewide models and maps; back-casting models to assess changes in infrastructure and habitats from 1972 to the present; and developing spatial models to assess the impacts of land-use change on sagebrush-obligate wildlife species and identify key resource needs for those species across large landscapes.





### **Assessing Threats to Sagebrush Habitats and Associated Species of Concern in the Wyoming Basins.**

The BLM manages roughly half of all habitat within the sagebrush biome. Consequently, management actions implemented by the BLM have the ability to impact large portions of sagebrush habitats and their dependent wildlife populations. FORT scientists, in collaboration with colleagues at the USGS Forest and Rangeland Ecosystem Science Center and the USDA Forest Service, have been working to (1) conduct an analysis of existing information to identify the primary land uses and their potential impacts on sagebrush habitats; (2) delineate the primary distribution of sagebrush habitats and identify wildlife species of conservation concern; (3) develop spatial models of species distributions and identify the areas most influenced by human activities; and (4) develop and implement procedures for sampling habitats to map the distribution and abundance of invasive species. In FY07, scientists completed analyses of empirical data collected over 2 years across Wyoming and drafted a final report for the BLM, which will be published as a multi-chapter book. The ecological models and analyses produced will help BLM managers make regional decisions regarding land-use activities and identify important resource needs and responses to land-use changes for key wildlife species.



### **Determining the Effects of Energy Development on Sagebrush Ecosystems.**

Sagebrush ecosystems are the foci of major conservation efforts, including research to elucidate the broad and complex scope of factors affecting them and projects to reverse or stabilize current rates of habitat fragmentation and loss. This is one of five research projects developed by the USGS to address priority needs for agencies and nongovernmental organizations that manage sagebrush habitats and wildlife. Through this project, FORT scientists are collaborating with scientists in other USGS science centers to conduct range-wide assessments of livestock grazing, including development of maps depicting grazing intensity and areas that succeed or fail to meet BLM's Land Health Standards. The research team also is assessing the impacts of energy developments on the distribution and abundance of invasive plant species. In FY07, scientists worked with BLM



**Greater sage-grouse chick. Photo by Cameron Aldridge, Colorado State University. Used with permission.**

staff to compile the spatial grazing data that will enable scientists to address questions regarding landscape-scale effects of grazing on sagebrush ecosystems and associated wildlife. Scientists also began designing a multistate sampling effort that will allow scientists to develop models predicting where and when exotic species are likely to become established, with a focus on disturbances associated with energy development. This work will be instrumental to an overall understanding of how land-use changes might affect sagebrush habitats and associated wildlife.



**Monitoring the Impacts of Off-Highway Vehicle Use on Wildlife.** Continued growth of off-highway vehicle (OHV) use has elevated concerns about the effects of OHV activities on wildlife habitat use. Quantifying these impacts is challenging because definitive results require simultaneous monitoring of OHVs and wildlife. Historically, researchers have used static metrics (road density, distance to roads) to explore the impacts of roads and road use on wildlife. Because temporal patterns in traffic and wildlife movements are absent from or poorly described in past analyses, little is known about how OHV traffic patterns affect wildlife. This project addresses that information gap through simultaneous use of GPS technology—which provides high-resolution (temporal and spatial) monitoring of wildlife movements—and a network of pneumatic traffic-monitoring equipment that documents vehicle numbers, type, speed, and direction of travel across the same landscape. In FY07, FORT scientists and USGS colleagues from the Geography Discipline and Geospatial Information Office expanded the existing OHV monitoring network and increased the sample size of GPS-marked elk. The data collected for this study are being used to model the impacts of OHV use on wildlife. Project collaborators include the USGS, BLM, NPS, USDA Forest Service, Colorado State University, and Colorado Division of Wildlife.



**Causes and Consequences of Bat Fatalities at Wind Turbines.**

Wind energy is one of the fastest-growing energy industries in the world, and wind turbines are killing thousands of bats each year in both North America and Europe. Causes of bat collisions with turbines remain undetermined, although migratory species that roost in trees (“tree bats”) are disproportionately affected. This project aims to determine the causes of bat collisions with turbines and assess the potential consequences of turbines on susceptible bat populations. In particular, FORT biologists are building upon their earlier studies of tree bat migration to help determine (1) the geographic origins of bats killed by turbines, (2) whether bats are attracted to turbines, and (3) whether mating and/or feeding behaviors play a role in fatalities. FORT biologists and collaborators at the USGS Stable Isotope and Gas Chemistry Laboratory in Denver are taking an integrated science approach to this work through the application of stable isotope techniques. Additional partnerships were established with the FWS, New York State Department of Environmental Conservation, and Point Reyes Bird Observatory (PRBO) Conservation Science. Results of this work will be applicable to assessing the health of tree bat populations and developing management strategies to minimize the impacts of turbines on bats. Results also will directly support current efforts by the FWS to establish guidelines for wildlife-friendly wind energy development.



**Wind turbines at dusk. Photo by Paul Cryan, USGS.**



**Using Stable Isotopes and Trace Elements to Link Seasonal Habitats of Neotropical Migratory Shorebirds.**

Identifying linkages between the seasonal habitats of migratory birds, especially neotropical migrants, is critical for effectively focusing conservation-based management efforts. For most neotropical migrants, however, virtually nothing is known about



which habitats are limiting, because the links between their seasonal habitats on different continents have not been clearly identified. Shorebirds that breed in the Arctic and winter in the southern hemisphere molt their flight feathers once per year, on the wintering grounds just prior to spring migration. Flight feathers carry chemical “markers” (stable isotopes) that are characteristic of the bird’s previous wintering area. Learning to interpret these distinct chemical markers in shorebird feathers would give us the ability to associate individual birds captured anywhere else (on the breeding grounds, in migration) with specific wintering sites, thereby helping to identify distinct areas used by different subpopulations. This task involves using stable isotope technology to interpret these chemical markers and test their efficacy in predicting a bird’s location, at a coarse spatial scale, at the time of molt. FORT is overseeing work being conducted by students from three universities in Argentina. Countrywide results through 2007 indicate that (1) isotope markers are highly variable within individual birds and within sites; and (2) the inherent variability may limit prediction of bird origin to broad regions rather than specific sites.



### **Improved Population Estimation Techniques and Immunocontraception Monitoring for Wild Horses and Burros.**

The BLM is responsible for managing 229 federally protected wild horse and burro herds located across more than 88 million acres of public land. With high reproductive rates and low natural mortality rates, wild horses represent challenges to managers seeking improved and scientifically sound techniques for maintaining healthy populations in balance with their habitats. FORT researchers are partnering with the BLM and Colorado State University to (1) test and refine the suite of new aerial population estimation techniques to improve their accuracy and (2) conduct field trials on immunocontraception for reducing reproductive rates in three wild horse herds. In FY07, FORT scientists continued monitoring the efficacy of immunocontraceptive treatments, seasonal patterns in parturition, and offspring health in the three trial herds. Work on aerial population estimation techniques included (1) completion of tests using mark-resight/sightability bias correction methods and (2) population modeling (based on data collected during 5 simultaneous double-count/sightability bias-correction flights) for the Adobe Town/Salt Wells Creek Herd Management Areas. The population estimates and modeling supported BLM herd management decisions on more than 2 million acres of public land in southern Wyoming.



**Wild horses at McCullough Peaks Wild Horse Management Area. Photo by Jason Ransom, USGS.**

## Sharing the Wealth: Access to Products

### Products and Publications

During FY07, FORT scientists delivered more than 140 products, 131 of which were publications (with several more in press). For a list of all our products, many of which are available online, visit <http://www.fort.usgs.gov/Products/>. [Appendix 1](#) lists publications from FY07 by USGS program element and goal.

## Sharing the Wealth: Access to Expertise

### Workshops



**Bird Migration Patterns in the Arid Southwest Using Doppler Radar.** Understanding the factors affecting migratory bird and bat populations during all three phases of their life cycle—breeding, nonbreeding, and migration—is critical to species conservation planning. Managers need information about these species’ responses to natural challenges as well as the effects of human activities and structures. Birds and bats are uniquely susceptible to human use of airspace. Wind turbines, communication and power transmission towers, and other tall structures known to cause bird and bat mortality are being erected or proposed in increasing numbers across the country. The biological data available from various radar technologies such as Doppler offer a unique opportunity to learn more about the distribution patterns, flight characteristics, and habitat use of “aerofauna.” FORT is leading the development of a USGS–FWS-sponsored coalition of Federal agencies and other scientists using radar technologies, along with additional partners who will use radar data to address issues concerning regulations, conservation, safety, wind power, and telecommunication cell towers. As part of this coalition, FORT hosted a workshop in October 2006 to strengthen and expand the existing USGS–FWS–university partnership and include new Federal agency partners. The subject matter centered on available technologies, appropriate applications, management-related needs, and ways to strengthen collaborative research and conservation efforts. The long-term focus of this coalition is to use these technologies to better understand movement patterns and habitat associations of migratory birds and other wildlife. This information will be valuable to the FWS and other landowners in dealing with regulatory issues of recent concern (e.g., the siting and permitting of communication towers and wind-power turbines known to cause bird mortality) as well as for habitat protection and management.



**Climate-Induced Forest Dieback as an Emergent Global Phenomenon.** For the 2007 meeting of the Ecological Society of America, a FORT ecologist organized and convened an oral session of 29 researchers representing 5 continents to explore whether climate-induced drought stress is triggering increasing rates and unusual patterns of forest dieback at a global scale. Attendees reported on patterns, mechanisms, and projections of forest mortality across millions of hectares in the West African Sahel, the Mediterranean and alpine regions of Europe, Patagonia, the Amazon Basin, western North America, and Australia. Contemporary tree mortality is often associated with multiple stress factors, including biotic agents (especially bark beetles), but mortality of grasses, cacti, and shrubs can be attributed to abiotic water stress from climate alone, suggesting that recent warm drought conditions are the primary drivers of forest die-off. This was supported by intensive analysis of regional forest inventory data documenting maximum

temperature as the key explanatory variable for tree mortality during the recent drought. The consequences of such drought-triggered ecosystem changes could fundamentally alter species associations around the world. More robust understanding of nonlinear physiological threshold responses to both chronic and acute water stress is required to improve future projections of tree mortality. Project collaborators include scientists from FORT and two other USGS biology centers, The Nature Conservancy, Universidad de Granada (Spain), Universidad Nacional del Comahue (Argentina), Queensland Herbarium (Australia), Northern Arizona University, and Los Alamos National Laboratory.



### **Wyoming Landscape Conservation Initiative (WLCI)**

The WLCI is a long-term, science-based effort to ensure that southwestern Wyoming's wildlife and habitats are sustained in the face of increasing land-use pressures, including energy extraction activities. In FY07, WLCI partners participated in a workshop to identify information needs and tools crucial to natural resource management, including identification of cumulative effects associated with development activities; key drivers of ecosystem change; condition and distribution of key wildlife species and habitats; wildlife and livestock responses to

development; most effective and needed restoration, reclamation, and mitigation activities and where such efforts would maximize conservation benefits; an integrated inventory and monitoring strategy; and a data clearinghouse and information management framework. FORT and other USGS scientists subsequently worked with WLCI partners to develop a draft Science Plan that provides multidisciplinary scientific and technical support to the WLCI and advances scientific understanding of southwestern Wyoming's ecosystems. For each area listed above, the plan outlines overall research objectives and both short- and long-term needs. The document's work plan integrates short-term research objectives within an overall research and monitoring framework. Formal partners (MOU signatories) in this major initiative include the USGS, BLM, FWS, USDA Forest Service, Wyoming Game and Fish Department, and Wyoming Department of Agriculture. The NPS, BOR, USDA Natural Resource Conservation Service (NRCS), Wyoming Department of Environmental Quality, and county governments are also collaborators.

**Technical Assistance on Habitat Assessment and Habitat Modeling.** DOI agencies, particularly the U.S. Fish and Wildlife Service, require significant support with their habitat assessments. Among a range of needs are models and computer software, training on Habitat Evaluation Procedures (HEP), and the expertise to design studies and conduct data analyses. HEP has become an accepted method of conducting habitat assessments in the United States as well as other countries such as Japan. Because FORT staff developed these procedures, the expertise to support clients, especially on complex issues, resides at FORT. Scientists (1) conduct training in the



**Oil drilling pad near Pinedale, Wyoming. Photo by Cameron Aldridge, Colorado State University. Used with permission.**

application of HEP, (2) develop new training courses in conjunction with the FWS National Conservation Training Center, (3) develop and test habitat models, (4) perform statistical design of field studies and habitat inventories, and (5) interpret and resolve ecological issues on complex project studies. In FY07, FORT hosted two workshops to assist the FWS with habitat assessments and to provide training on the associated techniques, including new Microsoft® Windows assessment software. The first of these workshops (held in Spokane, Wash.) focused on the Yakima River Basin Water Storage Feasibility Study to examine the feasibility and acceptability of water storage augmentation in the basin that would move the water regime towards a normative condition for salmonid migration and spawning. The second workshop (held in Reno, Nev., for a mixed group representing the FWS, BOR, and City of Reno) focused on restoration of Lahonton cutthroat trout habitat on a tributary of the Truckee River. Furthermore, two additional habitat assessment workshops were provided in Argentina to (1) a graduate student program at the Universidad Nacional de Córdoba and (2) a group of professional biologists at INTA (a national organization akin to our USDA) who conduct assessments of federal agricultural programs.

## Training



### Brown Treesnake Rapid Response Team Training Workshops.

Brown treesnakes have caused and continue to cause major problems for the ecology, economy, and quality of life on Guam. In 2002, a multiagency, USGS-led Rapid Response Team (RRT) was established to assist in the detection and capture of brown treesnakes on recipient islands after being accidentally transported from Guam. Since its creation, the RRT has conducted 2–5 training courses annually on Guam as well as 16 off-Guam field operations. As of 2007, the RRT consisted of 66 members located throughout the Pacific region and the United States mainland. The RRT has incorporated results from USGS research involving means to improve snake detectability at low densities, effectiveness of control tools in rodent-rich environments, and predicting movements of snakes translocated accidentally. In 2007, two full-length (18-day) training courses were conducted for new team members in June and September, and one 5-day refresher course was conducted in April. Cooperators include Guam Division of Aquatic and Wildlife Resources, USDA Wildlife Services, Hawaii Department of Agriculture, and Hawaii Department of Forestry and Wildlife. Additional quarantine and wildlife cooperators include officials from the Federated States of Micronesia, Republic of the Marshall Islands, Commonwealth of the Northern Mariana Islands, and Republic of Belau.

## How Do I Know I've Seen a Brown Treesnake?

**Length:** VARIES—commonly 1-1/2 ft. to 6 ft.


**Color:** The snake's back is light to dark brown and the belly is light yellow to white in color

**Pattern:** Shadowlike markings but no prominent blotches or stripes. Pattern may be very faint.

- **Body** is slender, with a long tail
- **Head** is wider than the neck
- **Eyes** are large with elliptical pupils (like a cat's)



NOTE:  
Wide head and slender body





Report Snake Sightings  
To your local authorities

Outreach poster template used to improve identification and increase awareness and reporting of brown treesnakes. Actual posters provide the local phone number to call for reporting a snake sighting. Graphic courtesy of James Stanford, USGS.



**Negotiation Training for Natural Resource Professionals.** Federal and State natural resource managers are entrusted with decision-making responsibilities for Federal and State resources. These decisions often are complex and involve many parties. With increasing emphasis on collaboration and stakeholder involvement, it is essential that resource managers acquire and refine negotiation skills. Decision makers are well trained in their professional fields, but lack training in negotiation processes. The negotiation training provided by FORT researchers addresses an acknowledged need. Social scientists at FORT have conducted research about natural resource conflict resolution and negotiation since the 1980s, and have provided training courses that in part draw from their findings. The courses are well grounded in classic negotiation theory but are enriched by the instructors' research. During FY 2007, FORT offered two classes in Basic Negotiation for Natural Resource Professionals (April and May), both of which were full with waiting lists, and one Advanced Negotiation for Natural Resources Professionals class in September, also full. Students were from a variety of Federal agencies (the USGS, BOR, USDA Forest Service, FWS, NPS, BLM, NRCS); State agencies (Colorado Department of Transportation, Department of Public Health and Environment; Missouri Department of Conservation, Department of Natural Resources; Wyoming Department of Environmental Quality; Ohio Department of Natural Resources; Vermont Department of Natural Resources); the Osage Tribe; and the University of Texas. Class evaluations were very positive, and feedback from previous or returning students indicates that the skills gained in these classes are extremely valuable and help managers make decisions.

**Training and Technical Assistance for Public Lands Management and Planning.** Passage of the 1997 Refuge Improvement Act requires the FWS to develop CCPs for more than 500 units of the National Wildlife Refuge System. The law and subsequent policies call for these plans to be based on sound science and to contain specific and measurable biological objectives. The FWS requires assistance in several aspects of CCP development, including incorporating the science, developing policy and guidance documents, and training. FORT social scientists assist the Division of Conservation Planning and Policy, National Wildlife Refuge System (FWS Headquarters), with the following:

- Reviewing internal draft CCPs to ensure compliance with FWS policies.
- Initiating development of an agency-wide preplanning guideline, with assistance from Headquarters and Regional Office staff.
- Participating in the redesign of the national CCP training course to ensure a stronger biological component.
- Conducting and/or participating in FWS region- or agency-wide workshops on goals and objectives consistent with the guidance contained in the Refuge goals and objectives handbook.
- Continuing to provide biological support for individual refuge CCPs.
- Publishing papers in peer-reviewed and other literature related to findings.

In FY07, FORT researchers analyzed current FWS policies related to planning and sustainability, and drafted a paper entitled "Comprehensive Conservation Planning and Sustainability within the National Wildlife Refuge System" for submission to the NBII-sponsored E-Journal, *Sustainability: Science, Practice, and Policy*. Additionally, FORT researchers provided support to individual refuges in several FWS regions regarding specific wildlife, habitat, and vegetation issues related to completion of the CCPs.

## Other Partnerships and Collaborations

- **Bats.** FORT scientists continued to work in collaboration with Colorado State University and the Centers for Disease Control on studies of rabies in bats (particularly on completing publications), finishing up a five-year study funded by the National Science Foundation and National Institutes of Health. FORT bat biologists are involved in developing new collaborative proposals on this topic.

In addition, FORT collaborated with University of Colorado Health Sciences Center virologists to study coronaviruses in bats. Together they documented and published the first evidence of coronaviruses in bats in the Western Hemisphere. Coronaviruses cause a variety of respiratory and enteric diseases in humans and domestic animals, and bats may be the origin of all coronaviruses known in birds and mammals. Additional study is ongoing, as is development of a National Institutes of Health proposal.

- **Radar.** Through a cooperative agreement with University of Southern Mississippi scientists, FORT is using NEXRAD Surveillance Weather Radar to understand bird migration patterns in the borderlands area of the arid Southwest. In addition, a FORT ecologist leads a USGS–FWS-sponsored coalition of Federal agencies, other scientists using radar technologies, and partners using radar data to address regulatory, conservation, safety, and power and telecommunications tower issues.
- **Stable Isotopes.** FORT continues cooperative relationships with three universities in Argentina. A FORT wildlife biologist is providing technical oversight for and serves on the committees of two students pursuing Ph.D.s. One is a student at the Universidad Nacional de la Patagonia, San Juan Bosco. The other received his M.S. degree from the Universidad Nacional de Córdoba and is now a Fulbright Scholar pursuing his Ph.D. at Colorado State University. A third student from the Universidad Nacional de La Pampa completed his senior project working with FORT staff. The cooperative research is being conducted between these universities and the USGS Geology and Biological Resources disciplines. Project goals are to evaluate the effectiveness of stable isotopes in identifying the winter location of migratory shorebirds in Argentina and to transfer technology and skills to Argentine resource managers.

## Customer Satisfaction

- Letter from James Moran, Vice Provost of Graduate Studies and Research at the University of Denver (DU), to Robert Dores (DU Department of Biological Sciences Chair) commending FORT conservation geneticist Sara Oyler-McCance:

*Dear Robert Dores:*

*I wanted to make you aware of Professor Sara Oyler-McCance's participation in the Partners in Scholarship program during the Spring 2006 and Summer 2006 academic quarters. Prof. Oyler-McCance served as a faculty partner to Robert Kysela and Michael Ramos.*

*Prof. Oyler-McCance and the students submitted a detailed proposal including a budget in order to be accepted for PINS funding. Prof. Oyler-McCance collaborated on research throughout the academic quarter and helped the students present their findings at a*

*quarterly luncheon as well as the annual undergraduate research Symposium. She volunteered her time to foster a partnership with the students and guide them throughout their research. Without the generous work of our faculty partners, the PINS program would not be possible. We are very grateful for Prof. Oyler-McCance's time, hard work, and enthusiasm while serving as a mentor to these students.*

*We would be delighted to have her serve as a PINS faculty partner in the future.*

- Email from Terry Rick, partners in Flight (PIF) National Coordinator, to FORT Research Ecologist Janet Ruth:

*Hi Janet,*

*I've attended a number of PARC planning meetings over the years, including the strategic planning session they held in Tucson last August. I've always been asked to share what I thought has helped PIF succeed. One thing that obviously has become more important over time—a piece that is now simply essential—is our web site. So, you can take quite a bit of credit for building and evolving our public face as we've needed it. To the outside, our web site IS Partners in Flight.*

*So...bask in the pleasure of a job well done!*

- Letter to FORT Research Wildlife Biologist Dean Biggins from Robert L. Vaught, Director of Renewable Resources for the USDA Forest Service, Rocky Mountain Region:

*Dear Dean,*

*I wanted to extend my thanks to you for speaking at the Regional Wildlife Workshop. Your presentation about plague and black-tailed prairie dogs was excellent and very useful to our biologists.*

*I appreciate your responsiveness in sharing your time and expertise. Thanks again.*

- Letter from John P. Cecil, Chair, Western Hemisphere Shorebird Reserve Network (WHSRN)-U.S., The U.S. Shorebird Conservation Plan, to Charles Duncan, Director, WHSRN Executive Office. The letter addresses a decision to designate Squaw Creek National Wildlife Refuge as a WHSRN site and the role played by Refuge Biologist Frank Durbian and FORT Wildlife Biologist Adrian Farmer's research:

*...The manuscript by Frank Durbian and Adrian Farmer does a great job demonstrating the survey rigor needed to obtain reliable and unbiased estimates of migrant shorebird populations. The Pectoral Sandpiper link between Squaw Creek and Siberia [Farmer's work] certainly adds a nice network flavor to this nomination.*



**Pectoral sandpiper. Photo by Robin Corcoran. Used with permission.**

*Squaw Creek staff has clearly placed a priority on managing for passage shorebirds and will continue to do so in the future....Squaw Creek NWR will be a welcome addition to the Western Hemisphere Shorebird Reserve Network.*

- July 17 email from Rick Schultz, U.S. Fish and Wildlife Service Chief, Division of Conservation Planning and Policy, to FORT Wildlife Biologist Rick Schroeder:

*Just wanted you to know that we have recognized you and four others for [your] dedication in developing and implementing the Refuge Comprehensive Conservation Planning training course at NCTC. I have heard good reviews from several about this course and I was also very impressed with the course for the day that I spent with you earlier this spring. No doubt that the [five] of you were instrumental in making this course a success. At any rate...thanks a bunch for what you have done!*

- Letter from Jerrilyn West, Chair, Colorado Field Institute, to FORT Ecologist Kate Schoenecker and Wildlife Biologist Linda Zeigenfuss:

*Dear Kate and Linda:*

*On behalf of the Colorado Field Institute, I would like to thank you for presenting the program "How Much Do They Love Plants? Let Us Count the Elk" on January 10. The update you provided on the elk and bison population research project in the San Luis Valley drew a diverse group of attendees who enjoyed your lecture, photos and tools. Your presentations complemented each other very well, providing insight into both the animals and the plants. While scientific in nature, your presentation held everyone's interest and educated us non-scientifically oriented folks.*

*We appreciate your time and effort in bringing this information to the San Luis Valley and helping CFI expand stewardship of the natural and cultural resources in the SLV through education.*

*Many thanks to both of you.*



**Biologists release a cow elk after taking body condition measurements and placing a radio collar on her for the USGS elk and bison grazing ecology study in the Great Sand Dunes National Park and Preserve and surrounding lands. Photo by Julie Mao, NPS. Courtesy of Kate Schoenecker.**

## **For More Information**

To learn more about FORT research staff, projects, science publications and other products, news, and events, please visit [www.fort.usgs.gov](http://www.fort.usgs.gov).



## Appendix 1. FORT Fiscal Year 2007 Publications and Products by USGS Program Goal

### A. FORT Publications Delivered in FY07

Pub Type	Program	Goal	Citation
<b>BIOLOGICAL INFORMATICS (BIO)</b>			
<b>BIO #1 – Increase the availability and usefulness of biological resources data and information (Content).</b>			
USGS Open-File Report	BIO	1	O'Shea, T.J. (Compiler). 2006. History of the Fort Collins Science Center, U.S. Geological Survey. Open-File Report 2006-1336. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 27 p.
USGS Open-File Report	BIO	1	Wilson, J.T. 2007. Fort Collins Science Center: 2006 accomplishments. Open-File Report 2007-1154. U.S. Geological Survey. 25 p.
<b>FISHERIES: AQUATIC AND ENDANGERED RESOURCES (FAER)</b>			
<b>FAER #2 – Provide scientific information about factors and processes that affect aquatic organism health in support of survival, protection, conservation and recovery.</b>			
Report	FAER	2	Chamberlain, C.D., and S.C. Williamson. 2006. Klamath River salmonid emigrant trapping catch, mortality, and external health indicators: 2004. U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata California. Arcata Fisheries Technical Report TR2006-06, plus supplement. Arcata, CA: U.S Fish and Wildlife Service, Arcata Fish and Wildlife Office. 102 + p.
Proceedings	FAER	2	Hanson, L., P.B. Shafroth, and F. D'Erchia. 2006. Tamarisk research priorities of land and water managers: results from a USGS partnership meeting. Fort Collins, CO: U.S. Geological Survey. 1 p.
USGS Open-File Report	FAER	2	McCormick, P., and S.G. Campbell. 2007. Evaluating the potential for watershed restoration to reduce nutrient loading to the Upper Klamath Lake, Oregon. Open-file Report 2007-1168. U.S. Geological Survey. 31 p.
<b>FAER #3 – Quantify and describe functional relationships among aquatic species and habitats to provide information to conserve or restore aquatic community structure and function.</b>			
Journal Article	FAER	3	Milhous, R.T., and J.M. Bartholow. 2006. Two analytical approaches for quantifying physical habitat as a limit to aquatic ecosystems. Journal of River Basin Management 4(3):191-1.
<b>FAER #6 – Provide research support and technical assistance to DOI bureaus, other Federal and State government agencies, Tribes, and non-governmental groups to support natural resource management problem solving and decision making.</b>			
Proceedings	FAER	6	Bovee, K.D. 2007. PowerPoint presentation: An overview of the upper Delaware River decision support system. Shepherdstown, WV: National Park Service. 22 p.
Proceedings	FAER	6	Bovee, K.D. 2007. PowerPoint presentation: An overview of the Instream Flow Incremental Methodology. Shepherdstown, WV: National Park Service. 1 p.
USGS Open-File Report	FAER	6	Bovee, K.D., T.J. Waddle, J. Bartholow, and L. Burris. 2007. A decision support framework for water management in the upper Delaware River. USGS Open-File Report 2007-1172. U.S. Geological Survey. 122 p.

## INVASIVE SPECIES (INV)

### INV #1 – Provide and coordinate the collection, synthesis, and accessibility of invasive species information (Information Management Goal)

Journal Article	INV	1	Crall, A.W., L. Meyerson, T.J. Stohlgren, C.S. Jarnevich, G.J. Newman, and J. Graham. 2006. Show me the numbers: what data currently exist for non-native species in the U.S.? <i>Frontiers in Ecology and the Environment</i> 4 (8):414-4.
Journal Article	INV	1	Fridley, J.D., J.J. Stachowicz, S. Naeem, D.F. Sax, E.W. Seabloom, M.D. Smith, T.J. Stohlgren, D. Tilman, and B. Von Holle. 2007. The invasion paradox: reconciling pattern and process in species invasion across spatial scales. <i>Ecology</i> 88(1):3-17.
Journal Article	INV	1	Jarnevich, C.S., J.J. Graham, G.J. Newman, A.W. Crall, and T.J. Stohlgren. 2007. Balancing data sharing requirements for analyses with data sensitivity. <i>Biological Invasions</i> 9:597-599.
Journal Article	INV	1	Stromberg, J.C., S.J. Lite, R. Marler, C. Paradzick, P.B. Shafroth, D. Shorrock, J.M. White, and M.S. White. 2007. Altered stream-flow regimes and invasive plant species: the Tamarix case. <i>Global Ecology and Biogeography</i> 16:381-393.

### INV #2 – Identify and report new invasions and assess risks to natural areas and waters (Early Detection & Rapid Assessment Goal)

Journal Article	INV	2	Bergquist, E., P. Evangelista, T.J. Stohlgren, and N. Alley. 2006. Invasive species and coal bed methane development in the Powder River Basin, Wyoming. <i>Environmental Monitoring and Assessment</i> DOI 10.100: 14.
Journal Article	INV	2	Boyarski, V.L., G.H. Rodda, and J.A. Savidge. 2007. Evaluation of harmonic direction-finding systems for detecting locomotor activity. <i>The Journal of Wildlife Management</i> 71(5):1704-1707.
Journal Article	INV	2	Christy, M.T., C.S. Clark, D.E. Gee II, D. Vice, D.S. Vice, M.P. Warner, C.L. Tyrrell, G.H. Rodda, and J.A. Savidge. 2007. Recent records of alien anurans on the Pacific island of Guam. <i>Pacific Science</i> 61(4): 469-483.
Journal Article	INV	2	Kalkhan, M.A., E.J. Stafford, P.J. Woodly, and T.J. Stohlgren. 2006. Assessing exotic plant species invasions and associated soil characteristics: a case study in eastern Rocky Mountain National Park, Colorado, USA, using the pixel nested plot design. <i>Applied Soil Ecology</i> 35:13.
Journal Article	INV	2	Kumar, S., T.J. Stohlgren, and G.W. Chong. 2006. Spatial heterogeneity influences native and nonnative plant species richness. <i>Ecology</i> 87(12):3186+.
Abstract	INV	2	Simonson, S.E., T.J. Stohlgren, and C.C. Landry. 2007. Plant species composition reveals temporal and spatial dynamics of snow slides in the San Juan Mountains, Colorado (abs.). In: <i>Ecological Society of America, San Jose California, August 2007</i> . San Jose, CA: Ecological Society of America. p. 1.
Proceedings	INV	2	Wiewel, A.S., G.H. Rodda, and A.A. Yackel Adams. 2006. Introduced rodent and shrew densities and distributions in the Mariana Islands: implications for Brown Treesnake control and management. Anchorage, Alaska: The Wildlife Society. 1 p.

**INV #3 – Assess changes in populations and distributions of established invaders (Monitoring and Forecasting Goal)**

Abstract	INV	3	Davern, T.R., T.J. Stohlgren, and R.M. Reich. 2006. Modeling invasive species using remote sensing: an example using Tamarix (abs.). In: The 2006 Tamarisk Research Conference: current status and future directions. October 3-4, 2006. Fort Collins, CO. Fort Collins, CO: Tamarisk Research Conference. p. 1.
Journal Article	INV	3	Savidge, J.A., F.J. Qualls, and G.H. Rodda. 2007. Reproductive biology of the brown tree snake, <i>Boiga irregularis</i> (Reptilia: <i>Colubridae</i> ), during colonization of Guam and comparison with that in their native range. <i>Pacific Science</i> 61(2):191-199.
Book	INV	3	Stohlgren, T.J. 2007. Measuring plant diversity: lessons from the field. New York: Oxford University Press. 390 p.
Journal Article	INV	3	Stohlgren, T.J., C. Flather, C. Jarnevich, D. Barnett, and J. Kartesz. 2006. Plant species invasions along the latitudinal gradient in the United States: a reply to Fridley et al. <i>Ecology</i> 87(12):3213+.
Journal Article	INV	3	Sutton, J.R., T.J. Stohlgren, and K.G. Beck. 2006. Predicting Yellow Toadflax infestations in the Flat Tops Wilderness of Colorado. <i>Biological Invasions</i> : 11.

**INV #4 – Provide approaches to contain, reduce, and eliminate populations of invasive species and restore habitats and native species (Control and Management Goal)**

Popular Article	INV	4	Rodda, G.H., J.L. Farley, and R. Bischof. 2007. New developments in barrier technology: Fly-ash covered wall offers a feasible alternative for permanent barriers to Brown Treesnake ( <i>Boiga irregularis</i> ). <i>Herpetological Conservation and Biology</i> . 2(2):157-163.
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**INV #5 – Conduct research and develop methods and technologies to prevent the introduction of invasive species (Prevention Goal)**

Journal Article	INV	5	Rodda, G.H., and J.A. Savidge. 2007. Biology and impacts of the Pacific Island Invasive Species. 2. <i>Boiga irregularis</i> , the Brown Tree Snake (Reptilia: <i>Colubridae</i> ). <i>Pacific Science</i> 61(3):307-324.
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**STATUS AND TRENDS OF BIOLOGICAL RESOURCES (ST)**

**ST #2 – Develop and evaluate inventory and monitoring methods, protocols, experimental designs, analytic tools, models, and technologies to measure biological status and trends.**

Pages in Book	ST	2	Biggins, D.E., J.G. Sidle, D.B. Seery, and A.E. Ernst. 2006. Estimating the abundance of prairie dogs. In: Hoogland, J.L., (ed.). Conservation of the black-tailed prairie dog: saving North America's western grasslands. Washington, D.C.: Island Press. p. 94+.
USGS Science Investigations Report	ST	2	Biggins, D.E., J.L. Godbey, M.R. Matchett, L.R. Hanebury, T.M. Livieri, and P.E. Marinari. 2006. Monitoring black-footed ferrets during reestablishment of free-ranging populations: Discussion of alternative methods and recommended minimum standards. In: J.E. Roelle, et al. (eds.). Recovery of the black-footed ferret: progress and continuing challenges: proceedings of the Symposium on the Status of the Black-footed Ferret and Its Habitat, Ft. Collins, CO, Jan. 28-29, 2004. Sci. Invest. Rpt. 2005-5293. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 155-173.
Journal Article	ST	2	Farmer, A., and F. Durbian. 2006. Estimating shorebird numbers at a migration stopover site. <i>The Condor</i> 108: 792+.

Abstract	ST	2	Stanley, T.R., and S.K. Skagen. 2007. Estimating the breeding population of long-billed curlew in the United States (abs.). In: American Ornithologists' Union annual meeting, August 9, 2007 in Laramie, WY. American Ornithologists' Union. p. 11.
<b>ST #3 – Collect, archive, and share selected, critical, high-quality monitoring data in cooperation with our partners to enable a determination of the status and trends of biological resources.</b>			
Book	ST	3	Nelson, S.M., and D.C. Andersen. 2007. Las Vegas Wash water quality monitoring program 2006 report of findings. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation. 50 p.
Serial	ST	3	Ramotnik, C.A. 2006. Handling and care of dry bird and mammal specimens. Conserve O Gram Number 11/9. Washington, DC: U.S. National Park Service, Park Museum Management Program. 5 p.
USGS Admin Report	ST	3	Ramotnik, C.A., and M.A. Bogan. 2007. Museum of Southwestern Biology UNM Department of Biology calendar year 2006. Museum of Southwestern Biology Annual Report. Fort Collins, CO: U.S. Geological Survey. 9 p.
<b>ST #4 – Produce and provide analyses and reports that synthesize information on the status and trends of our Nations flora, fauna, and ecosystems and are responsive to the needs of the scientific community, land and resource managers, policy makers, and the public.</b>			
Journal Article	ST	4	Burkardt, N., and P.D. Ponds. 2006. Using role analysis to plan for stakeholder involvement: a comparison of three workshops. Wildlife Society Bulletin 34(5):1306-1313.
Fact Sheet	ST	4	Burkardt, N., M.E. Swann, and K. Walters. 2006. Negotiation training courses for natural resources professionals. Fact Sheet 2006-3116. Fort Collins, CO: U. S. Geological Survey, Fort Collins Science Center. 1 p.
USGS Open-File Report	ST	4	Cline, R., N. Sexton, and S.C. Stewart. 2007. A human-dimensions review of human-wildlife disturbance: a literature review of impacts, frameworks, and management solutions. Open-File Report 2007-1111. U.S. Geological Survey. 88 p.
Pages in Book	ST	4	Gregory, S., A.W. Allen, M. Baker, K. Boyer, T. Dillaha, and J. Elliott. 2007. Realistic expectations of timing between conservation and restoration actions and ecological responses. In: M. Schenpf and C. Cox (eds.). Managing agricultural landscapes for environmental quality: strengthening the science base. Ankeny, IA: Soil and Water Conservation Society. p. 115-146.
Journal Article	ST	4	King, D., N. Burkardt, and B.L. Lamb. 2006. Pigs on the plains: institutional analysis of a Colorado water quality initiative. International Journal of Public Administration 29(14):1411-1430.
Journal Article	ST	4	Kokaly, R.F., S.L. Rockwell, S.L. Haire and T.V.V. King. 2007. Characterization of post-fire surface cover, soils, and burn severity at Cerro Grande Fire, New Mexico, using hyperspectral and multispectral remote sensing. Remote Sensing of Environment 106:305-325.
WWW	ST	4	Kotliar, N.B. 2007. Olive-sided flycatcher ( <i>Contopus cooperi</i> ): a technical conservation assessment. <a href="http://www.fs.fed.us/r2/projects/scp/assessments/olivesidedflycatcher.pdf">http://www.fs.fed.us/r2/projects/scp/assessments/olivesidedflycatcher.pdf</a> .
Journal Article	ST	4	Morrison, R.I.G., B.J. McCaffery, R.E. Gill, S.K. Skagen, S.L. Jones, G.W. Page, C.L. Gratto-Trevor, and B.A. Andres. 2006. Population estimates of North American shorebirds, 2006. Wader Study Group Bulletin 111:67-85.



Journal Article	ST	4	Ponds, P.D. 2007. Taking charge of the wild: Keep an eye on “unmanaged” trails. Parks and Recreation 42(6):32-37.
Popular Article	ST	4	Sexton, N.R. 2006. Science for planning: It's more than just the biology! Management Tracks: News from the Organization of Wildlife Planners. 20(2):6.
Proceedings	ST	4	Sexton, N. 2007. Q Methodology: A Tool for Facilitating Public Discourse in Natural Resources Decision-making. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 2 p.
USGS Open-File Report	ST	4	Sexton, N.R., and S.C. Stewart. 2007. Understanding knowledge and perceptions of bats among residents of Fort Collins, Colorado. USGS Open-File Report 2007-1245. U.S. Geological Survey. 22 p.
USGS Open-File Report	ST	4	Sexton, N.R., S.C. Stewart, L. Koontz, P. Ponds, and K.D. Walters. 2007. Visitor and community results for Prime Hook National Wildlife Refuge: Completion report. Open-File Report 2007-1239. Fort Collins, CO: U. S. Geological Survey, Fort Collins Science Center. 222 p.
Abstract	ST	4	Stanley, T.R., and S.K. Skagen. 2007. Estimating the breeding population of long-billed curlew in the United States (abs.). In: American Ornithologists' Union annual meeting, August 9, 2007, Laramie, WY. American Ornithologists' Union. p. 11.
Journal Article	ST	4	Taylor, J.G., S.C. Gillette, R.W. Hodgson, J.L. Downing, M.R. Burns, D.J. Chavez, and J.T. Hogan. 2007. Informing the network: improving communication with interface communities during wildland fire. Human Ecology Review 14(2):198-211.
Journal Article	ST	4	Taylor, J.G. 2007. Introduction to special section on fire human ecology. Human Ecology Review 14(2):163-164.
Journal Article	ST	4	Yackel Adams, A.A., S.K. Skagen, and J.A. Savidge. 2007. Population-specific demographic estimates provide insights into declines of Lark Buntings ( <i>Calamospiza melanocorys</i> ). The Auk 124(2):578-593.

### TERRESTRIAL, FRESHWATER, AND MARINE ECOSYSTEMS (ECO)

#### **ECO #1 – Quantify and understand factors influencing patterns of temporal and spatial variability in key ecosystem components and processes.**

USGS Open-File Report	ECO	1	Andersen, D.C. 2007. Road impacts on the Baca National Wildlife Refuge, Colorado, with emphasis on effects to surface- and shallow ground-water hydrology: A literature review. Open-File Report 2007-1052. U.S. Geological Survey. 26 p.
Journal Article	ECO	1	Auble, G.T., J.E. Roelle, and A. Timberman. 2006. Riparian willow restoration at Arapaho National Wildlife Refuge. Green Line, Colorado Riparian Association Newsletter 17(4):1-5.
Proceedings	ECO	1	Bowen, Z., and G. Auble. 2006. Channel change from the prescribed release on Marias River, MT. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 8 p.
Journal Article	ECO	1	Kotliar, N.B., P.L. Kennedy, and K. Ferree. 2007. Avifaunal responses to fire in southwestern montane forests along a burn severity gradient. Ecological Applications 17(2):491+.
Journal Article	ECO	1	Nelson, S.M., and D.C. Andersen. 2007. Variable role of aquatic macroinvertebrates in initial breakdown of seasonal leaf litter inputs to a cold-desert river. Southwestern Naturalist 52(2):219-228.

Book	ECO	1	Nelson, S.M., and D.C. Andersen. 2007. Las Vegas Wash water quality monitoring program 2006 report of findings. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation. 50 p.
Journal Article	ECO	1	Northcott, K., D.C. Andersen, and D.J. Cooper. 2007. The influence of river regulation and land use on floodplain forest regeneration in the semi-arid Upper Colorado River Basin, USA. <i>River Research and Applications</i> 23:565-577.
USGS Open-File Report	ECO	1	Shafroth, P.B., and V.B. Beauchamp, (eds.). 2006. Defining ecosystem flow requirements for the Bill Williams River, Arizona. Open-File Report 2006-1314. Reston, VA: U.S. Geological Survey. 135 p.
Popular Article	ECO	1	Stephenson, N., D. Peterson, D. Fagre, C. Allen, D. McKenzie, and J. Baron. 2006. Response of western mountain ecosystems to climatic variability and change: The Western Mountain Initiative. <i>Park Science</i> . 34(1):24-29 p.

**ECO #2 – Model factors controlling ecosystem patterns at various scales and develop decision support systems which integrate this information with management options.**

Journal Article	ECO	2	Hartman, M.D., J.S. Baron, and D.S. Ojima. 2006. Application of a coupled ecosystem-chemical equilibrium model, DayCent-Chem, to stream and soil chemistry in an alpine watershed. <i>Ecological Modeling</i> 200:493+.
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**ECO #4 – Devise restoration and adaptive management frameworks for impaired ecosystems.**

Journal Article	ECO	4	Nichols, E., J. Baron, R. Dirzo, J. Sarukhan, A. Persic, S. Arico. 2007. New ecological knowledge and practices for society and sustainability. <i>Frontiers in Ecology and Environment</i> 5(4):W5-W7.
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**WILDLIFE: TERRESTRIAL AND ENDANGERED RESOURCES (WTR)**

**WTR #1 – Provide the scientific foundation for the conservation of terrestrial plants, wildlife, and habitats by developing the basic biological information that partners need to formulate adaptive management strategies.**

Abstract	WTR	1	Aldridge, C.L. 2007. Sagebrush steppe restoration and sage-grouse (abs.). In: <i>Restoring the West 2007 Sagebrush Steppe Restoration Conference</i> , Logan, UT. p. 1.
Abstract	WTR	1	Baker, B.W. 2006. Prairie dogs as keystone engineers of sagebrush and grassland bird communities in the U.S. and Mexico (abs.). In: <i>Wings without borders: 4th North American Ornithological Conference</i> , Veracruz, Mexico, October 3-7, 2006. Waco, TX: North American Ornithological Conference. p. [1].
USGS Science Investigations Report	WTR	1	Biggins, D.E. 2006. The symposium in context. <i>Scientific Investigations Report</i> 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 3-5.
Journal Article	WTR	1	Biggins, D.E., and D.M. Biggins. 2006. Bobcat attack on a cottontail rabbit. <i>Southwestern Naturalist</i> 51(1):119-1.
USGS Science Investigations Report	WTR	1	Biggins, D.E., J.L. Godbey, M.R. Matchett, and T.M. Livieri. 2006. Habitat preferences and intraspecific competition in black-footed ferrets. <i>Scientific Investigations Report</i> 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 130+.
Pages in Book	WTR	1	Cryan, P.M., and J.P. Veilleux. 2007. Migration and the use of Autumn, Winter, and Spring roosts by tree bats. In: M.J. Lacki, J.P. Hayes, and A. Kurta, (eds.). <i>Bats and Forests</i> . Baltimore, MD: The Johns Hopkins University Press. p. 153-175.

Journal Article	WTR	1	Dominguez, S.R., T.J. O'Shea, L.M. Oko and K.V. Holmes. 2007. Detection of group 1 coronaviruses in bats in North America. <i>Emerging Infectious Diseases</i> 13(9):1295-1300.
Journal Article	WTR	1	Ellison, L.E., T.J. O'Shea, D.J. Neubaum, and R.A. Bowen. 2007. Factors influencing movement probabilities of big brown bats ( <i>Eptesicus fuscus</i> ) in buildings. <i>Ecological Applications</i> 17(2):620-627.
Journal Article	WTR	1	Ellison, L.E., T.J. O'Shea, J. Wimsatt, R.D. Pearce, D.J. Neubaum, M.A. Neubaum, and R.A. Bowen. 2006. Field sampling blood from big brown bats ( <i>Eptesicus fuscus</i> ) with and without anesthesia: impacts on survival. <i>Journal of Wildlife Diseases</i> 42(4):849-8.
USGS Admin Report	WTR	1	Iko, W.M., R.J. Dusek, and E.K. Hofmeister. 2007. Measuring the effects of West Nile Virus on wild American Kestrels ( <i>Falco sparverius</i> ) populations in Colorado: 2005 year-end report. Administrative Report. Fort Collins, CO: U.S. Geological Survey. 15 p.
Journal Article	WTR	1	Lehmer, E.M., D.E. Biggins, and M.F. Antolin. 2006. Forage preferences in two species of prairie dog ( <i>Cynomys parvidens</i> and <i>C. ludovicianus</i> ): implications for hibernation and facultative heterothermy. <i>Journal of Zoology</i> 269:249+.
Journal Article	WTR	1	Lehmer, E.M., L.T. Savage, M.F. Antolin, and D.E. Biggins. 2006. Extreme plasticity in thermoregulatory behaviors of free-ranging black-tailed prairie dogs. <i>Physiological and Biochemical Zoology</i> 79(3):454+.
Journal Article	WTR	1	Mettenbrink, C.W., V.J. Dreitz, and F.L. Knopf. 2006. Nest success of Mountain Plovers relative to anthropogenic edges in eastern Colorado. <i>Southwestern Naturalist</i> 51:191-196.
USGS Science Investigations Report	WTR	1	Muths, E., A.L. Gallant, E.H. Campbell Grant, W.A. Battaglin, D.E. Green, J.S. Staiger, S.C. Walls, M.S. Gunzburger, and R.F. Kearney. 2006. The Amphibian Research and Monitoring Initiative (ARMI): 5-year report. Scientific Investigations Report 2006-5224. Reston, VA: U.S. Geological Survey. 77 p.
Journal Article	WTR	1	Muths, E., R.D. Scherer, P.S. Corn, and B.A. Lambert. 2006. Estimation of temporary emigration in male toads. <i>Ecology</i> 87(4):1048-1056.
Journal Article	WTR	1	Muths, E., C.P. Lyons, and J.A. Sedgwick. 2007. Blue jays nest in an unusual structure. <i>The Passenger Pigeon</i> 69(1):33.
USGS Admin Report	WTR	1	O'Shea, T.J., P.M. Cryan, L.E. Ellison, and E.W. Valdez. 2007. Bat use of coniferous forests at Mesa Verde National Park: Year 1 progress report (unpublished). Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 162 p.
USGS Admin Report	WTR	1	Oyler-McCance, S.J. 2007. Final Report for "Microsatellite analysis of population structure in mountain plover" (unpublished). Denver, CO: Submitted to the U.S. Fish and Wildlife Service. 19 p.
Journal Article	WTR	1	Pearce, R.D., and T.J. O'Shea. 2007. Ectoparasites in an urban population of big brown bats ( <i>Eptesicus fuscus</i> ) in Colorado. <i>Journal of Parasitology</i> 93(3):518-530.
Journal Article	WTR	1	Schneider, S.C., M.B. Wunder, and F.L. Knopf. 2006. The relationship of low-growing shrubs and forage availability to mountain plovers in South Park, Colorado, USA. <i>Southwestern Naturalist</i> 51(2):197-202.

USGS Open-File Report	WTR	1	Schoenecker, K.A., B.C. Lubow, L.C. Zeigenfuss, and J. Mao. 2006. 2005 annual progress report: elk and bison grazing ecology in the Great Sand Dunes complex of lands. Open-File Report 2006-1267. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 45 p.
Journal Article	WTR	1	Sedgwick, J.A. 2006. Once upon a time in American ornithology. Wilson Journal of Ornithology 118:264-266.
Journal Article	WTR	1	St. John, J., F.A. Ransler, T.W. Quinn, and S.J. Oyler-McCance. 2006. Characterization of microsatellite loci isolated in trumpeter swan ( <i>Cygnus buccinator</i> ). Molecular Ecology Notes 6:1083+.
Abstract	WTR	1	Weller, T.J., and P.M. Cryan. 2007. Broadening our focus on the conservation of bats in the United States (abs.). In: Abstract of presentation to the 14th International Bat Research Conference, Merida, Mexico, 20-23 August 2007. p. 1.

**WTR #2 – Provide tools and techniques, such as predictive models, decision support, and expert systems, for science-based management of wildlife and plant populations and their habitats.**

USGS Science Investigations Report	WTR	2	Harrington, L.A., D.E. Biggins, A.W. Alldredge. 2006. Modeling black-footed ferret energetics: are southern release sites better? Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 286+.
USGS Open-File Report	WTR	2	Lubow, B.C., and J.I. Ransom. 2007. Aerial population estimates of wild horses ( <i>Equus caballus</i> ) in Adobe Town and Salt Wells Creek Herd Management Areas using an integrated simultaneous double-count and sightability bias correction technique. Open-File Report 2007-1274. U.S. Geological Survey. 13 p.

**WTR #3 – Identify the factors that contribute to and/or limit the conservation and recovery efforts for terrestrial plant and wildlife species-at-risk.**

Pages in Book	WTR	3	Biggins, D.E., B.J. Miller, T.W. Clark, and R.P. Reading. 2006. Restoration of an endangered species: the black-footed ferret. In: Groom, M.A., G.K. Meffe, and C.R. Carroll (eds.). Principles of conservation biology. Sunderland, MA: Sinauer Associates. p. 581+.
USGS Science Investigations Report	WTR	3	Biggins, D.E., J.L. Godbey, T.M. Livieri, M.R. Matchett, and B.D. Bibles. 2006. Postrelease movements and survival of adult and young black-footed ferrets. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 191+.
USGS Science Investigations Report	WTR	3	Biggins, D.E., J.M. Lockhart, and J.L. Godbey. 2006. Evaluating habitat for black-footed ferrets: revision of an existing model. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 143.
USGS Science Investigations Report	WTR	3	Breck, S.W., D.E. Biggins, T.M. Livieri, M.R. Matchett, and V. Kopcsó. 2006. Does predator management enhance survival of reintroduced black-footed ferrets? Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 203.
USGS Admin Report	WTR	3	Cryan, P.M. 2007. Emergence counts of endangered long-nosed bats ( <i>Leptonycteris curasoae</i> and <i>L. nivalis</i> ) at major roosts in southwestern New Mexico. Final Administrative report: Submitted to the Bureau of Land Management's Las Cruces District Office. Administrative Report. Fort Collins, CO. 1 p.



Pages in Book	WTR	3	Cully, J.F., D.E. Biggins, and D.B. Seery. 2006. Conservation of prairie dogs in areas with plague. In: Hoogland, J. (ed.). Conservation of the black-tailed prairie dog: saving North America's western grasslands. Washington, D.C.: Island Press. p. 157-161.
USGS Science Investigations Report	WTR	3	Godbey, J.L., D.E. Biggins, and D. Garelle. 2006. Exposure of captive black-footed ferrets ( <i>Mustela nigripes</i> ) to plague ( <i>Yersinia pestis</i> ) and implications for species recovery. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 233+.
USGS Science Investigations Report	WTR	3	Hanebury, L.R., and D.E. Biggins. 2006. A history of searches for black-footed ferrets. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 47-57.
USGS Science Investigations Report	WTR	3	Marcum, S.N., D.E. Biggins, and J.A. Clarke. 2006. Effects of moonlight on cover usage and spatial learning of black-footed ferrets. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 284+.
Journal Article	WTR	3	O'Shea, T.J., and L.B. Poche, Jr. 2006. Aspects of underwater sound communication in Florida manatees ( <i>Trichechus manatus latirostris</i> ). Journal of Mammalogy 87(6):1061+.
USGS Admin Report	WTR	3	Oyler-McCance, S.J. 2006. Sage-Grouse genetics research in North America 1999-2006: a summary. Administrative Report. U.S. Geological Survey. 26 p.
USGS Admin Report	WTR	3	Oyler-McCance, S.J., and J. St. John. 2006. Final report for genetic portion of "Colony dynamics of the endangered Indiana myotis ( <i>Myotis sodalis</i> ) using and comparing standard field techniques and molecular genetic techniques." Administrative Report. U.S. Geological Survey. 19 p.
USGS Admin Report	WTR	3	Ramotnik, C.A. 2006. Impact of the Scott Able Fire on Sacramento Mountain Salamander abundance and arthropod prey base. Final report. Administrative Report. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 80 p.
USGS Admin Report	WTR	3	Ramotnik, C.A., and M.A. Bogan. 2006. UNM Museum of Southwestern Biology Annual Report for calendar year 2005: U.S. Geological Survey contribution. Administrative Report. 10 p.
USGS Admin Report	WTR	3	Sparks, D.W., D.J. Judy, and J.O. Whitaker, Jr. 2007. Colony dynamics of the endangered Indiana bat ( <i>Myotis sodalis</i> ) using and comparing standard field techniques and molecular genetic techniques: Year II field techniques progress report, 2006. U.S. Geological Survey. Administrative Report. 48 p.
USGS Science Investigations Report	WTR	3	Wimsatt, J., D.E. Biggins, E.S. Williams, and V.M. Becerra. 2006. The quest for a safe and effective canine distemper virus vaccine for black-footed ferrets. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 248+.

**WTR #5 – Enhance USGS wildlife research to meet emerging and future issues. Build additional capabilities, expertise, and capacity in the WTR Program to meet the emerging needs of USGS partners as wildlife issues take on new importance in today's society.**

USGS Science Investigations Report	WTR	5	Biggins, D.E., J.L. Godbey, B.J. Miller, and L.R. Hanebury. 2006. Radio-telemetry for black-footed ferret research and monitoring. Scientific Investigations Report 2005-5293. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. p. 175+.
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Abstract	WTR	5	Cryan, P.M., M.A. Bogan, C.D. Weise. 2006. Nocturnal movements of two endangered species of <i>Leptonycteris</i> (Chiroptera: <i>Phyllostomidae</i> ) in an area of sympatry in southwestern New Mexico (abs.). In: American Society of Mammalogists 86th Annual Meeting, Amherst, MA. 17-21 June 2006. Amherst, MA: American Society of Mammalogists. p. [1].
Abstract	WTR	5	Cryan, P.M. 2007. Patterns of bat fatalities at wind energy facilities (abs.). In: Abstract of presentation given at the Wildlife Society's 14th Annual Conference, Tucson, AZ, 22-26 September 2007. p. 1.
Abstract	WTR	5	Cryan, P.M. 2007. Mating systems of tree bats and the emerging problem of bat fatalities at wind turbines (abs.). In: Abstract of presentation to the American Society of Mammalogists, June 7, 2007, Albuquerque, NM p. 1.
Journal Article	WTR	5	Cryan, P.M., and A.C. Brown. 2007. Migration of bats past a remote island offers clues towards the problem of bat fatalities at wind turbines. <i>Biological Conservation</i> 139:1-11.
WWW	WTR	5	Farmer, A., J. Wilson, and B. Olson. 2006. Godwits on the go: Using satellite technology to track migrating marbled godwits. <a href="http://www.fort.usgs.gov/GoGodwits/">http://www.fort.usgs.gov/GoGodwits/</a> .
USGS Admin Report	WTR	5	Felix, R., R. Diehl, and J.M. Ruth. 2007. Bird migration patterns in the arid Southwest: Year II. U.S. Geological Survey Administrative Report. Fort Collins, CO: U.S. Geological Survey, Fort Collins Science Center. 17 p.
Journal Article	WTR	5	King, T.L., J.F. Switzer, C.L. Morrison, M.S. Eackles, C.C. Young, B. Lubinski, and P. Cryan. 2006. Comprehensive genetic analyses reveal evolutionary distinction of a mouse ( <i>Zapus hudsonius preblei</i> ) proposed for delisting from the U.S. Endangered Species Act. <i>Molecular Ecology</i> 15: 4331+.
Proceedings	WTR	5	O'Shea, T.J., R.A. Bowen, and C.E. Rupprecht. 2006. Ecology of commensal bats in relation to rabies transmission: excerpts of the Fort Collins study, 2001-2005. U.S. Geological Survey, Fort Collins Science Center: Fort Collins, CO. 11 p.
Abstract	WTR	5	O'Shea, T.J., R.A. Bowen, L.E. Ellison, M.L. Farnsworth, and C.E. Rupprecht. 2006. Ecology of commensal bats in relation to rabies transmission: summary of the Fort Collins study, 2001-2005 (abs.). In: 86th Annual Meeting of the American Society of Mammalogists, Amherst, Massachusetts. Amherst, MA: American Society of Mammalogists.
Proceedings	WTR	5	Ruth, J.M., D.J. Krueper, A. Manville, L. Randall, W. Barrow, and S. Johnston. 2006. Applying radar technology to migratory bird conservation and management: Strengthening and expanding a collaborative effort. Workshop participant notebook for USGS-USFWS workshop held 24-25 October 2006. Albuquerque, NM: USGS-USFWS Workshop. 63 p.
Popular Article	WTR	5	Wilson, J.T. and A. Farmer. 2006. Satellites used to track bird movement and preserve species. <i>People, Land and Water</i> 12(5):1.
WWW	WTR	5	Wilson, J.T., and A. Farmer. 2006. Godwits on the go. <a href="http://www.fort.usgs.gov/Resources/GoGodwits/">http://www.fort.usgs.gov/Resources/GoGodwits/</a> .

## B. Other FORT Products Delivered in FY07

Product Type	Program	Goal	Citation
<b>Biological Informatics #2 – Develop, integrate, and apply tools that maximize the efficiency and effectiveness of user interactions with biological data and information.</b>			
Web application	BIO	2	Fisheries Information System (FIS: reporting enhancements; ECOS.fws.gov/fis)
Web application	BIO	2	Integrated Single Sign-On capabilities (ECOS.fws.gov)
Web application	BIO	2	Habitat Information and Tracking system (HabITS; web service enhancements; ECOS.fws.gov/habits)
Web application	BIO	2	Information, Planning and Consultation System (IPaC; prototype development; ECOS.fws.gov/ipac)
Web application	BIO	2	Consulted on Effects Database (CED; ECOS.fws.gov/coed)
Web application	BIO	2	Tracking and Integrated Logging System (TAILS; reporting enhancements; ECOS.fws.gov/tails)
Web application	BIO	2	Recovery Online Activity Reporting (ROAR; Phase II system enhancements; ECOS.fws.gov/roar)
Web application	BIO	2	Government Performance and Reporting Act 2007 (GPRA; ECOS.fws.gov/esgpra)
Web application	BIO	2	Recovery Data Call 2007 (RDC; TESS; ECOS.fws.gov)
Web application	BIO	2	Candidate Information (Candidate; TESS; reporting and major data model enhancements; ECOS.fws.gov/tess/Candidate)
Web application	BIO	2	My USGS (my.usgs.gov)
Web application	BIO	2	Environmental Contaminates Database Management System (ECDMS; data model enhancements and architectural updates; ECOS.fws.gov/ecdms)
Web application	BIO	2	Coastal Grants Program Web sites (ECOS.fws.gov/coastal_grants)
<b>Fisheries: Aquatic and Endangered Resources #6 – Provide research support and technical assistance to DOI bureaus, other Federal and State government agencies, Tribes, and non-governmental groups to support natural resource management problem solving and decision making.</b>			
Software	FAER	6	Bovee, K.D., T.J. Waddle, J. Bartholow, and L. Burris. 2007. The Delaware River decision support system: version 2.11 [computer software]. Fort Collins, CO: Fort Collins Science Center.