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Fort Collins Science Center: 2006 Accomplishments

By Juliette Wilson, Ed.¹

Science for Resource Management

In Fiscal Year 2006 (FY06), the U.S. Geological Survey (USGS) Fort Collins Science Center (FORT) continued research vital to U.S. Department of the Interior (DOI) science and management needs and associated USGS programmatic goals. FORT work also supported the science needs of other governmental departments and agencies as well as private cooperators. Specifically, FORT scientific research and technical assistance focused on client and partner agency 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. Highlights of FORT project accomplishments are described below under the USGS science program area with which each task is most closely associated.²

The work of FORT's five branches (in 2006: Aquatic Systems and Technology Applications, Ecosystem Dynamics, 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). These are noted using the following symbols:



= major collaborative venture,



= integrated science projects involving other USGS disciplines.

Biological Information Management

Activities in this area support the development and application of products and tools that facilitate effective, efficient use of biological data and information. Several of these also contribute to generating and providing knowledge about the status and trends of living resources.



Web Applications for Natural Resource Information Management. FORT's Technology Applications Team (TAT) continues to provide technical support, Web applications development, and training for a range of projects for the U.S. Fish and Wildlife Service (FWS) and USGS. One is the Environmental Conservation Online System (ECOS; <http://ecos.fws.gov>), a suite

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² Several tasks related to research in sagebrush ecosystems, which fall primarily under the categories of "Terrestrial Ecosystems" and "Wildlife Resources," are instead described under *New Science Initiative: Energy and Land-Use Development Research and Technical Assistance*.

of ecological data storage, retrieval, and mapping applications serving the FWS and the public. In FY06, TAT delivered 8 new ECOS applications and 2 new Web sites, along with 1 prototype application and 6 beta releases. The number of registered ECOS users surpassed 3,000 this year; user data processing now averages 700,000 transactions/day, including generation of 60,000 maps/day. Again this year, TAT maintained the National Biological Information Infrastructure Southwest Information Node (SWIN) and enhanced the SWIN Science Information Database.



Vegetation Mapping for National Parks. The USGS-National Park Service Vegetation Mapping Program (USGS-NPS VMP) is in the process of developing vegetation cover maps for most units in the National Park system. Vegetation cover maps are critical for managing park units. Two issues are prominent: (1) many parks currently have no maps or very old maps, and (2) new methodologies are needed to increase the speed and accuracy of vegetation mapping, reduce the cost, and produce a quantitative-based vegetation database. In two projects, FORT tackled both of these. ***Comparative Vegetation Mapping for Lassen Volcanic National Park.*** Working with the USGS-NPS VMP, FORT established a research project to compare the widely used, traditional aerial photo-interpretation methodology with the relatively new Discrete Classification Mapping Methodology (DCMM). The DCMM may be a more accurate and efficient



mapping methodology that the USGS-NPS VMP will want to consider for mapping other medium-to-large parks. This 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). In FY06, the project was initiated and field data collection for both mapping efforts were completed. The overall project will be complete in FY08. ***Vegetation Mapping for the Canyon de Chelly National Monument and Mesa Verde National Park.*** In a second project, FORT collaborated with the USGS-NPS VMP and the Southern Colorado Plateau Network to complete half of the photo-interpretation and 100 percent of the GIS automation to produce a draft vegetation cover map for the Canyon de Chelly National Monument.

FORT received eCognition-derived polygons from the USGS Rocky Mountain Geographic Science Center (RMGSC) and worked with staff at RMGSC to help determine the most appropriate set of eCognition polygons to use for mapping the vegetation at Mesa Verde National Park. FORT completed this task and produced a draft vegetation cover map using reference aerial photographs and field visits in consultation with RMGSC staff.

Mapping Weed Presence in Dryland Cropping Systems. Farmers need distribution maps of weeds in their fields to reduce herbicide use by applying site-specific weed management (SSWM). Although remote sensing is key to successful weed mapping, methods of varying cost and complexity are needed for the widest adoption of SSWM. FORT staff worked with the U.S. Department of Agriculture (USDA) Agricultural Research Service, Water Management Research Unit, to develop a system for mapping weed cover in fallow dryland cropping that is low-cost, easy to use, and does not require expensive GIS, GPS, and image-analysis software. The system includes a consumer digital camera and GPS unit, commercial software to map locations of images and view the image at each location, and image analysis and map-viewing software that FORT developed.

FORT staff use a pseudo-Normalized Difference Vegetation Index with a shadow adjustment to identify weed pixels. Weed cover in an image is calculated as the percent of pixels classified as green. Locations are displayed using a color legend for percent weed cover and are linked for viewing original and analyzed images. Locations can also be mapped on aerial photographs, topographical maps, or shape files of information such as crop yield.

Fisheries and Aquatic Resources

Activities related to fish and aquatic resources involve research and technical assistance that promotes 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.



Colorado River Endangered Fish. Field surveys of the federally endangered razorback sucker were conducted in FY06 on the Colorado River from Davis Dame to Lake Havasu and on Lake Mohave. Using a combination of boat surveys and high-resolution digital aerial photography, researchers tested the efficiency and effectiveness of these survey methods for finding and counting these unique fish. Boat surveys, which involve surface counts and electrofishing, appear to be a cost-effective alternative to traditional trammel-net fish sampling, which has the significant drawback of sometimes catching water birds and mammals in addition to fish. Evaluation of aerial surveys, flown in winter when the reservoir is clear and shallow, will continue into FY08. In a related task, researchers conducted studies to determine whether physical conditioning and predator recognition behavior could be enhanced in hatcheries and thereby improve short-term stocking survival rates. Razorback suckers were subjected to water velocities of 30 cm/s for 10 weeks and given predator survival tests. Results showed that survival of velocity-conditioned fish exposed to predators was 22 percent greater than in non-conditioned fish. This work demonstrated that predator avoidance by razorback suckers was a learned behavior, and that physical conditioning improved survival.



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Lake Havasu Fishery Management Memorandum of Understanding (MOU). An MOU was signed in FY06 to implement the multi-agency Lake Havasu Fishery Enhancement Program, established to optimize habitat conditions for improved recreational fishing. The USGS is a signatory along with the U.S. Bureau of Land Management, U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, Arizona Department of Game and Fish, and California Fish and Game Department. The group's purpose is to oversee and make recommendations on the program, which included one-time stocking of 30,000 bonytail and 30,000 razorback suckers. Both are endangered species native to the Colorado River. A FORT scientist is the primary scientific contact for this work and is monitoring these native fish populations using the survey methods described above.

Decision Support System (DSS) for the Upper Delaware River. FORT scientists delivered to the Delaware River Basin Commission Version 2.0 of a DSS prototype for predicting the effects of different water management strategies on habitat for fish and mussels in the upper Delaware River Basin. As input to the DSS, investigators used two-dimensional models of habitat for trout, American shad, and dwarf wedgemussels at 11 sites in the East and West Branches, the mainstem Delaware, and the Neversink River, and at 15 different discharges in each river. This input enables the DSS to quantify and display changes for a variety of decision variables that result from changes in reservoir operations and water supplies. Several modifications were made in response to stakeholder comments and perceived needs. The final report, with Version 2.1 documentation, is in preparation.

Decision Support System Template for the Yakima River. FORT scientists provided to U.S. Bureau of Reclamation staff a prototype DSS template for their review and suggested revisions. The DSS will support water management decisions by quantifying changes in salmonid habitat in the Yakima River, Wash., resulting from changes in water supply (by transbasin diversion from the Columbia River) and reservoir operations. Placeholders have been reserved in the DSS template for model outputs as they become available from cooperators. Investigators conducted a Delphi exercise to define the habitat characteristics to be used in developing habitat maps for each of the target species and life stages. Habitat-versus-discharge maps have been completed for various life stages of salmon and steelhead for one of five floodplain reaches in the Yakima. Output from these maps is used to develop look-up tables for flows and salmonid habitat used in the DSS.

Klamath River Modeling for Federal Energy Regulatory Commission (FERC) Re-licensing. Water supply and quality, as they pertain to anadromous fish life-cycle needs, are the principal components of a variety of modeling applications for the Systems Impact Assessment Model (SIAM) on the Klamath River. The FERC license for hydropower projects on the mainstem Klamath River below Upper Klamath Lake expired in March, 2006. SIAM was used to analyze fall Chinook salmon run-timing, spring flow variability, use of full-active reservoir storage potential to affect water temperature, hypothetical dam removal, restoring anadromous fish above the mainstem dams, historical fish production variability and fish production model sensitivity, potential for variable outlets to affect water temperature, and spring pulse flow effects. The model application did not identify any single source of mortality acting as a true “bottleneck.” Many of these analyses provided information for documents prepared by the FWS as part of the FERC re-licensing effort. Two journal publications and one open-file report were prepared in FY06 with the results from these analyses.

Invasive Species

Research on invasive species supports (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; and (4) developing and testing control and management strategies.

Tamarisk Control Research. Tamarisk, or salt cedar, is an exotic plant species that has invaded riparian areas throughout the West. Multi-agency efforts toward controlling and removing tamarisk are ongoing and more are proposed. FORT scientists are working on several levels to assist Federal and State land and water management agencies by providing sound science for effective decision-making. Projects include leading research coordination and information exchange

among the many involved agencies, tribes, and private groups; developing predictive models to estimate vegetation changes and their effects on water supply in response to different flow regimes; and researching tamarisk ecology and the effectiveness of different management, control, and removal processes. Ongoing 2006 research discovered hybridization between two *Tamarix* species that has apparently introduced the genetic variability necessary for rapid evolution of the latitudinal gradient in cold hardiness; that is, plants in Montana are hardier than those from Texas.



Effects of Spatial Scale on Patterns of Plant Invasions in the Central United States. Invasive non-native plant species cost our Nation billions of dollars in control, affecting agricultural production and grazing, fire return intervals, and native plant diversity in natural areas. Predicting which species will invade and which habitats will be invaded requires collecting field data at the appropriate spatial scales. In this study of 36 vegetation types across the central United States, the FORT research team with the USGS National Institute of Invasive Species Science (NIISS) discovered through FY06 data analysis that typical 1-m² plots greatly underestimated invasion potential, and that multi-scale and larger-scale plots are needed to accurately predict vulnerability to invasion. The proposed field and analysis methods can be applied on all DOI lands. They are featured in a new book by FORT/NIISS investigator Tom Stohlgren (*Measuring Plant Diversity*, 2006, Oxford University Press), and in recent journal articles.

New System for Sensitive Data Sharing on Invasive Species. Data sharing is a critical component for knowledge of non-native, invasive species distributions to create watch lists, predictive models, and an early warning rapid-response system. Invasive species do not recognize political boundaries, making it necessary for resource managers in different agencies to know what species are found in their vicinity. Data can be sensitive for many reasons, precluding data sharing, especially if the data are from private lands or include the location of a novel biological control agent. FORT staff have developed a system available on the NIISS Web site (www.niiss.org) that synthesizes disparate datasets shared by different users, including a mechanism to mark locations as sensitive. Sensitive data are “fuzzed” to all but the contributor for the mapping application and data download, but can still be used for analyses. This technique to overcome the problems of data sensitivity is featured in an upcoming article in *Biological Invasions*.

Creating a 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 over 500 National Wildlife Refuges. In cooperation with the FWS, FORT’s research team at the National Institute of Invasive Species Science developed and tested a volunteer network to map invasive species. Researchers developed sampling protocols, trained refuge staff, and advised volunteers from the local community on gathering extensive field data on high-priority weeds in the Hart Mountain national Antelope Refuge in Oregon. They also gathered plot data to create maps and models of key invaders and to guide further surveys. The team created a generalized protocol, called “The Art and Science of Weed Mapping,” that will be published after expanding and testing the system at three additional refuges across the country in 2007. Creating networks of trained volunteers for invasive species surveys is the first step in creating a cost-efficient early detection and rapid response program in the National Wildlife Refuge System.

Coal Bed Methane (CBM) Development Effects on the Establishment on Non-native Plants. Rapid expansion of energy resources in the central United States requires a detailed understanding of potential environmental impacts. Working closely with U.S. Bureau of Land Management officials, FORT investigators evaluated the vegetation and soil characteristics of well pads, water release areas, and “undisturbed/control” sites in the Powder River Basin, Wyo. They found increased invasion on CBM-developed areas, reduced native plant diversity on pads, and extensive invasion in water release areas. However, control sites were also invaded to some degree. This pilot study suggested the need for a more extensive regional evaluation of cumulative effects of CBM development and associated infrastructure (roads and fences) relative to background conditions.

Filling in Data Gaps for Native and Non-native Species Using Modeling Techniques. Knowledge of species richness patterns for both native and non-native species is an important component of setting conservation priorities. Many large-scale datasets exist, but these datasets often suffer from incomplete sampling. In this study using county-level species lists, our research team at the NISS took spatially incomplete datasets and used the best sampled areas to develop models that could predict the richness of native and non-native species in poorly sampled areas. A key finding was that native species richness was the best predictor of non-native species richness. These methods, featured in a recent article in *Diversity and Distributions*, can be applied at different spatial scales and for different taxonomic groups important to Federal land management.

Modeling Capture Probability of the Invasive Brown Treesnake. The brown treesnake is a highly destructive, non-native species introduced on Guam in the 1940s that has extirpated most of the island’s native bird species, as well as bats and lizards. Trapping is one of the main techniques currently used to detect and control brown treesnake populations. Heterogeneity (variability) in trap-capture probabilities poses a serious challenge for control efforts, particularly control programs directed at eradicating an incipient or nearly extirpated population. In order to facilitate the development and refinement of detection and control technologies, project biologists identified and quantified the factors that affect capture probability of brown treesnakes. FORT scientists are using these factors to model capture probabilities as a function of individual covariates (size, sex, condition, prior capture history, etc.) and latent (unexplained) heterogeneity. Improvement in our understanding of the causes of heterogeneity will not only refine our ability to strategically plan eradications, but also will greatly improve the precision of abundance estimates.



Documenting Introductions and Pathways of Invasion of New Exotic Prey Species on Guam. Shipping and air traffic out of Guam provides opportunities for the destructive, invasive brown treesnake (BTS) to be transported to other islands and beyond. Lizard and amphibian species are the primary prey of small BTS on Guam. Small size classes of BTS are least likely to be intercepted by current trapping interdiction efforts and are also the size class most often detected in cargo. Thus, keeping the prey base for small snakes as low as possible in order not to increase juvenile survival seems desirable in preventing accidental snake transport to Hawaii and other Pacific islands. This study documented new exotic frog species introductions to Guam and provided an overview of the various pathways by which they entered the island. The identification of major pathways allows for strategic targeting of prevention efforts. Targeting pathways rather than indi-

vidual species is a more productive approach to invasive species control, because each pathway can be a vector for a suite of organisms.

Status and Trends of Biological Resources

Status and trends research identifies ongoing or impending changes to species, habitats, and ecosystems. A primary goal is to “provide a framework that [integrates] information from a variety of sources at multiple spatial and temporal scales to describe and track the abundance, distribution, productivity, and health of the Nation’s plants, animals, and ecosystems.” Related 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.



MOU Established for Florida Manatee Multi-Agency Integrated Database. The Florida manatee is listed as federally endangered and is protected under the Marine Mammal Protection Act. To assist in ongoing management, conservation, and recovery efforts, FORT scientists developed the Manatee Individual Photo-identification System (MIPS). This computerized database contains photographs of uniquely scarred manatees and their individual life histories. Information from this database is used to estimate population parameters, model manatee population dynamics, identify the level of incidental take by watercraft, assess impacts of hydrological changes, and evaluate management alternatives for State and Federal natural resource managers. Recently, the USGS, Florida Fish and Wildlife Conservation Commission, and Mote Marine Laboratory signed a Memorandum of Understanding to consolidate once-separate databases dating back to the 1970s into a single distributed database. This move has improved the efficiency of data management, ensures quality and compatibility of the data, and greatly facilitates continuing efforts to advance manatee research in response to the needs of State and Federal managers. FORT has the lead in developing, managing, and maintaining this integrated MIPS database. To date, over 137,000 photographs (dating back to the 1960s and representing observations from all partners) of approximately 4,000 individual manatees have been scanned and shared among the partners.

Effects of West Nile Virus on Bird Populations. Since West Nile virus (WNV) was discovered in New York in 1999, the disease has spread among bird populations in all 48 conterminous States and 5 Canadian provinces. Two of the most affected bird groups are raptors and corvids. However, the potential impacts of WNV on wild raptor populations are currently unknown. To address this issue, two collaborative efforts between FORT and the USGS National Wildlife Health Center (NWHC) have been developed to monitor raptors in northern Colorado and raptors and shorebirds at the Salton Sea in southern California. These collaborations include the FWS Rocky Mountain Arsenal National Wildlife Refuge (NWR) and Sonny Bono Salton Sea NWR, and the USGS Salton Sea Science Authority. At several sites located



along the Front Range of northern Colorado, 3 years of monitoring WNV impacts on American Kestrels generated over 2,421 samples from an average of 120 breeding adults and 260 nestlings each breeding season. At the Salton Sea, 208 American kestrels, 118 burrowing owls, and 494 shorebirds were serologically sampled for West Nile virus in the vicinity of the Sonny Bono Salton Sea NWR to provide baseline information to the USGS Salton Sea Science Office and the USFWS Sonny Bono National Wildlife Refuge on the prevalence of WNV in the selected avian species at the Salton Sea. Blood and oral swab samples from both studies are currently being analyzed at the laboratories of the USGS National Wildlife Health Center, Madison, Wisc.

New Text on Standardized Measurement of Plant Diversity. A new textbook authored by FORT scientist Tom Stohlgren, entitled *Measuring Plant Diversity: Lessons from the Field*, was released in 2006 by Oxford University Press. The book provides detailed inventory and monitoring methods, sampling designs, analytical approaches, and spatial model descriptions to measure the status and trends of plant diversity. The first such textbook of its kind, it will help provide standardized approaches to multi-scale, landscape-scale surveys of native and non-native species. The book represents over 10 years of research backed by dozens of peer-reviewed journal articles.

Estimating the Breeding Population of Long-billed Curlew. Long-billed Curlews are a species of special concern in North America due to apparent declines in their population. Because Long-billed Curlews are not adequately monitored by existing programs (for example, the North American Breeding Bird Survey), at the request of U.S. Fish and Wildlife Service FORT undertook a two-year study with the goals of (1) determining present Long-billed Curlew distribution and breeding population size in the United States, and (2) providing recommendations for a long-term Long-billed Curlew monitoring protocol. Investigators randomly sampled survey routes in 15 western States in 2004 and 2005, then analyzed count data from these routes to estimate detection probabilities and abundance. These estimates of breeding individuals in 2004 and 2005 far exceed currently accepted estimates based on expert opinion. Results showed that Long-billed Curlews were patchily distributed within their range and were present and presumably breeding in areas with relatively little native grassland. The study report makes recommendations for improving sampling methodology and presents power curves to provide guidance on minimum sample sizes required to detect trends in abundance.



Integrating Agriculture and Conservation. Assistance to the USDA Farm Service Agency (FSA) focused on refinement of management of lands enrolled in the CRP and



other conservation programs administered by the USDA. In cooperation with the Kansas Department of Wildlife and Parks, field data collection was completed on a two-year study to determine effects of incidental cattle grazing on linear conservation practices associated with winter grazing of crop stubble fields. Results of this investigation have the potential to show that conservation policies and viable economic uses are complementary uses of agricultural lands. FORT scientists completed an investigation of the Farmable Wetlands Program and delivered a final report and presentation of management implications for these lands to

FSA headquarters staff. In cooperation with the USDA Natural Resources Conservation Service, Colorado State University, and a private landowner, FORT scientists continued an investigation of grazing to refine management of CRP grassland in the shortgrass steppe. This long-term study has the potential to refine agricultural conservation policies and make them more beneficial to both agricultural operations and wildlife endemic to shortgrass ecosystems. In addition, FORT staff provided assistance to the Wildlife Management Institute and FSA pertaining to a National Corn Grower Association request for documentation of conservation program effectiveness in the Little Blue River watershed of Kansas and Nebraska. Key findings of this investigation highlighted the interest of landowners for continued participation in conservation programs, their desire for information describing local results, communication of this information to the general public, and the need for local assessments of the effectiveness of conservation policies.

Public Knowledge and Perception of Bats. Bats are reservoirs for viruses that can potentially impact the health of humans and other mammals. Along Colorado's Front Range, bats are finding new roosts in homes and buildings (commensalism) as urbanization diminishes the availability of natural roosts. This puts bats and people in greater likelihood of contact and thus at increased risk for disease transmission. This collaborative study involves scientists from FORT, Colorado State University, and the Centers for Disease Control and Prevention. The objective is to expand the very limited knowledge base on public knowledge, perceptions, and preferences concerning bats and disease transmission by investigating the human dimensions impacts of commensal bats and humans. Such information is vital for managing bats and developing effective communications protocols regarding bat disease and ecology. In FY06, FORT investigators analyzed data and presented findings at The Wildlife Society's annual meeting. They also developed a draft report of survey results to share with partners and interested survey respondents. Papers for submission to peer-reviewed journals are underway.



Assessing the Use of Geospatial Data in Response and Recovery Efforts for Hurricanes Katrina and Rita. Substantial resources were committed to provide geospatial data for response and recovery efforts after Hurricanes Katrina and Rita. USGS personnel from all disciplines contributed to the development of GIS for the Gulf and compiled, collected, copied, and delivered geospatial data. FORT social scientists and the Chief Scientist for the USGS Salton Sea office, formerly Chief of the Technical Support Section of the USGS National Geospatial Technical Operations Center-IV in Seattle, assessed the use of geospatial data provided to first responders and other decision-makers for response and recovery after these hurricanes. The scientists conducted interviews with approximately 50 individuals who provided or used geospatial data and are in the process of analyzing the interview transcripts. Findings will focus on characteristics of the data, data delivery systems, and organizational incentives or barriers to communication and data sharing. Although much attention has been paid to lessons learned from the hurricanes, this is the only project of which the scientists are aware that systematically assesses geospatial data use from the perspective of both providers and users.

MOUs Established for Research and Training on Negotiation. During FY06, the USGS entered into Memorandums of Understanding with two major research institutions: the Natural Resource Leadership Academy (NRLA) at Washington State University in Pullman, Wash., and the Houston Advanced Research Center (HARC) in Houston, Tex. FORT and the NRLA will cooperate in providing alternative dispute resolution training to natural resource professionals. FORT social scientists offer training in natural resource negotiation, and NRLA staff provide training in stewardship, communication, leadership, and collaborative decision making. The NRLA serves State, local, and tribal governments. Initial efforts will focus on cross-listing courses, and ongoing work will identify additional courses that could be developed. The mission of the Social and Policy Analysis Group (SPA) at the HARC is to conduct social science research on the social, economic, and policy aspects of sustainable development. Under the terms of the MOU, social scientists at FORT and SPA propose to collaborate on training and research related to negotiating natural resource agreements. FORT and SPA also share an interest in the evaluation of negotiation methodology and propose to collaborate on research that will evaluate the conditions under which negotiation is warranted.



Training and Technical Assistance to the U.S. Fish and Wildlife Service for Refuge Planning. The U.S. Fish and Wildlife Service is required by law to develop a Comprehensive Conservation Plan (CCP) for each of the 545 refuges within the National Refuge System. These plans require the use of sound science and high-quality biological objectives, and FORT has been working closely with the FWS to provide technical assistance with this national planning effort. In FY06, FORT scientists provided on-site assistance, such as workshops for biological objectives and synthesis of scientific information, to the following refuges: Rainwater Basin Wetland Management District, Lacreek NWR, Long Lake NWR, and Arapaho NWR and satellite refuges. FORT staff continue to play a major role in training courses for improving the scientific quality of CCPs. They instructed the biological sections of the national CCP course during November 2005 and March 2006 and continue to receive positive feedback on both courses. They also taught biological sections of the online FWS Habitat Management Planning course in March 2006. Further collaboration in FWS courses is in the planning stages, including development of an online national CCP course and a course through the FWS National Conservation Training Center related to monitoring for biological objectives.



Research Supporting the Comprehensive Conservation Planning Process for National Wildlife Refuges. The Comprehensive Conservation Plan (CCP) for each National Wildlife Refuge must contain an analysis of local social and economic conditions and evaluate social and economic results from likely management scenarios. FORT researchers continue to provide assistance with CCP development for 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. Specific accomplishments include the following:

- **Socioeconomic Analysis of Alternative Transportation Planning for Kilauea Point National Wildlife Refuge, Kauai, Hawaii:** A completion report for visitor and community survey results for this refuge was finalized and presented to the FWS and Hawaii Department of Transportation, who used the results to develop conceptual alternatives for an Alternative

Transportation Plan. Refuge managers also used the results to act on other issues, such as initiating a new fee booth.

- **Socioeconomic Analysis for Lake Umbagog, Prime Hook, and Rappahannock River Valley National Wildlife Refuges:** In FY06, FORT social scientists conducted, completed, and delivered results of surveys of refuge stakeholders and community members to inform development of various public-use alternatives for the three refuges in crafting their CCPs. Also, refuge staff at Lake Umbagog used information from an economic impact analysis FORT completed in early FY06 to address socioeconomic impacts in the Environmental Impact Statement for the refuge's CCP.
- **Stakeholder Assessments for Canaan Valley National Wildlife Refuge:** In FY06, FORT social scientists developed a stakeholder list for the refuge based on a content analysis of Web sites and newspaper articles from the past 5 years. Refuge staff used this list to ensure that they are contacting appropriate stakeholders as they begin the scoping process of their CCP planning. Planned work includes an in-depth stakeholder assessment and stakeholder workshop to clarify issues for inclusion in the plan.
- **Stakeholder and Planning Team Assessments for Cabeza Prieta National Wildlife Refuge:** To help the refuge in its planning process related to CCP development and in particular the social science questions, FORT staff conducted an assessment of both identified stakeholders and the planning team. Stakeholders were evaluated in terms of their preference for process (negotiation or arbitration) and their preference for outcome (status quo or change) in identifying and addressing planning issues. They found that stakeholders perceived negotiation as the most likely process, and that parties were very mixed in their views of whether the status quo was an acceptable outcome. They also found that the planning team was not unified in their view on these questions. These results, which were shared with the planning team, are important because successful negotiation teams must share a common understanding of the structure and goals of a problem in order to speak with one voice and reach agreement.

Terrestrial Ecosystems

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



USGS Science Informs Air Quality Policy in Colorado.

More than 23 years of monitoring and research by USGS scientist Jill Baron and colleagues (including scientists with the USGS-Water Resources Discipline) have documented marked ecological and water quality changes from high nitrogen levels in Rocky Mountain National Park. In 2006, these results led officials with the National Park Service, the Environmental Protection Agency Region 8, and the Colorado Department of Public Health and Environment to sign an MOU to develop air quality management policies and pro-



grams addressing harmful impacts to air quality and other natural resources in the Park. Together the agencies will develop a nitrogen deposition goal and related standards assisted by Dr. Baron's paper, "Hindcasting nitrogen deposition to determine an ecological critical load," which appeared in the April 2006 issue of *Ecological Applications*.



Results of Bighorn Sheep Studies. Like many populations of bighorn sheep in the West, bighorn sheep in the greater Bighorn Canyon National Recreation Area (BICA) of Montana and Wyoming were extirpated in the late 1800s. A small herd was reintroduced to the area in 1973 and increased to about 211 animals. Then, for unknown reasons, the population declined sharply in the mid-1990s. The numbers leveled off at around 100 animals by 1998. In 2000, at the request of National Park Service resource managers, FORT researchers began a study to evaluate (1) the causes for this decline, (2) herd population dynamics, and (3) why sheep weren't using all the suitable habitat available to them. The study area included BICA, the adjacent Pryor Mountain Wild Horse Range, and surrounding State and Federal lands in Montana and Wyoming.

In the 2006 report, *Bighorn Sheep Habitat Studies, Population Dynamics, and Population Modeling in Bighorn Canyon National Recreation Area, Wyoming and Montana, 2000–2003* (http://www.fort.usgs.gov/Products/Publications/pub_abstract.asp?PubID=21300), authors present the results of studies on bighorn sheep population dynamics and population modeling, herbivory and vegetation studies, and habitat modeling.



Recovery after Wildfire. By October 2006, wildfires throughout the West had consumed more than 9.1 million acres of wildland, the highest as of this date in 10 years, and new fires were developing daily. Families living in communities hit by such fires face years of coping with the aftermath. FORT staff and a handful of local partners developed a community-based approach, the Volunteer Task Force, that engaged Los Alamos, N.M., citizens and schools in post-fire rehabilitation and environmental education. Task Force efforts—including coordination of more than 70,000 volunteer hours since the summer of 2000, when the Cerro Grande fire burned some 43,000 acres—are catalyzing the recovery of the ecosystem, and they continue to help the residents recover as well. The techniques applied in Los Alamos also have assisted other fire-affected communities in the Southwest. In addition, FORT scientist John Hogan has led countless educational/field-work trips with local students who collect data and help with restoration activities in a burned watershed as part of learning about fire and forest ecology in their community. As an outgrowth of this work, Mr. Hogan was a primary coauthor responsible for developing *Investigating Fire Ecology in Ponderosa Pine Forests: A Curriculum for Sixth Grade*. In 2006, this curriculum earned an Educator's Award from the National Association of Interpreters.

Wildlife 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.



Wild Horse and Burro Research for the U.S. Bureau of Land Management (BLM).

The BLM is responsible for managing 229 wild horse and burro herds located across more than 88 million acres of public land. Accurate herd counts lie at the heart of management decisions concerning herd and habitat health. FORT researchers are working with the BLM and Colorado State University to test aerial survey techniques for more accurate population estimates, and they are also conducting field trials on immunocontraception in horse herds. In 2006, FORT scientists completed the final applications of fertility control to mares in two Herd Management Areas, and provided managers with pregnancy test results from treated mares in all three research herds. The fertility control applications conducted by FORT in the Little Book Cliffs (Colorado) has decreased the foaling rate by 43 percent in the last three years, thus reducing the physical and financial burdens associated with capture and removal strategies for population reduction. Behavioral and demographic data collected during FY06 provided real-time adaptive management information for BLM wild horse specialists and for analysis of key research questions. Tests of aerial population estimation techniques continued in FY06; FORT coordinated with BLM herd managers to conduct joint surveys on all flights. Models for analyzing the aerial survey data were refined in FY06 and applied to all recent survey results to further improve estimation techniques.



Endangered Bat Conservation. Three species of nectar- and pollen-feeding bats are critical to the health and maintenance of ecosystems in the borderland area. The lesser long-nosed bat and greater long-nosed bat are endangered, and the Mexican long-tongued bat is a candidate for listing. All three species are jeopardized by vandalism and destruction of roosting sites, killing by humans, and loss of habitat and food resources. FORT scientists recently completed a study of the distribution, abundance, and roosting behavior of the bats in southwestern New Mexico to inform U.S. Bureau of Land Management conservation and management activities affecting the bats and their associated desert ecosystems. Of substantial interest is the discovery of a natural cave roost on BLM lands in the Big Hatchett Mountains, which houses the largest known colony in the United States comprising both lesser and greater long-nosed bats. Over 5,000 bats were counted exiting from one of the two known entrances to this new roost. Another new roost was discovered in the Animas Mountains as well. The roost in the Big Hatchett Mountains is over 30 km to the east of the Animas roost and falls outside the known range of both species. The discovery of these additional roosts suggest that adequate roosting habitat for the two species in the region may be more common than previously suggested, and that both species of long-nosed bat have more extensive ranges in southwestern New Mexico than previously believed.



Ecology of Rabies Transmission in Commensal Bat Colonies. FORT bat biologists have completed field and laboratory phases of a collaborative venture with Colorado State University and the Centers for Disease Control and Prevention in Atlanta on the ecology of rabies

transmission in big brown bats. This work was supported by the National Science Foundation and the National Institute of Health's Ecology of Infectious Diseases program, of which the USGS was a founding partner. FORT biologists concentrated on determining the population dynamics and ecology of bats that roost in human-occupied buildings in Fort Collins, Colo. They also coordinated field sampling of marked and released bats for serological studies of antibodies and determination of rabies virus in bat saliva. The 5-year study spanned disciplines ranging from molecular studies of genetic variants of the virus to seasonal migrations of the bats and integrated modeling to characterize the overall rabies transmission dynamics. This study has revealed a unique capacity of bats to acquire a degree of immunity to this virus, heretofore typically considered fatal in mammals. The unique application of passive integrated transponders for individual identification and remote monitoring of bats formed the foundation for determining bat survival rates (a key component of host dynamics) in relation to multiple ecological factors. The work is now concentrating on final data analysis and comprehensive modeling of the bat population–rabies transmission system.

Bat Use of Coniferous Forests at Mesa Verde National Park. In FY06, FORT biologists initiated a new study of bats at Mesa Verde National Park as part of the Natural Resource Preservation Program. Nearly 1,000 bats were captured, identified, and released as they drank or foraged over water during this first summer of study. New distribution records for two species of bats were established for this park, and 2006 capture records documented 15 species of bats that use Mesa Verde. Selected individuals of multiple species were radio-tracked to determine roosting locations of reproductively active females. Most of these bats favored roosting in rock crevices, particularly in steep canyon cliff faces. For these bats, the recent extensive wildfires in piñon-juniper woodlands may not have severely impacted roosting habitat. This research has also revealed the existence of at least three maternity colony sites for spotted bats at Mesa Verde, the first such records for the State of Colorado.

Mountain Lion Research in Rocky Mountain National Park. The mountain lion is Colorado's top predator and one of Rocky Mountain National Park's most charismatic species. As park visitation increases, so does the likelihood of human-cat encounters. Information on the ecology and movements of park pumas is critical to managers. FORT and the Colorado Division of Wildlife



(CDOW) are investigating the ecology and behavior of these little understood residents. The CDOW study tested lion-killed mule deer for chronic wasting disease, while the FORT study investigates all aspects of mountain lion ecology: birth and death rates, movement, home range, population dynamics, and mountain lion–human interactions. FORT is also testing noninvasive capture methods. This year the research team captured 5 lions in and around the Park, fitted them with GPS collars, and developed preliminary maps of habitat usage. They also collected video footage of behavior at kill sites.



Black-footed Ferret Recovery: Progress and Continuing Challenges. The black-footed ferret was formally recognized on the very first endangered species list and has had a history of devastating losses and remarkable successes ever since. Incrementally through time, researchers and managers have progressed in understanding the issues complicating ferret recovery and how to manage or overcome these challenges. In anticipation of the upcoming need to evaluate

the status of ferrets and update the Recovery Plan, the U.S. Fish and Wildlife Service requested FORT's assistance in jointly hosting a symposium to evaluate the progress of black-footed ferret recovery and identify next steps to advance ferret recovery. The 2004 symposium provided a forum for disseminating existing information and bringing together technical experts and resource managers to collaboratively discuss necessary future actions. Much of the information presented at this forum—on ferret behavior, physiology, management requirements, available habitat, and factors affecting survival and recovery—had not been readily available for use in recovery planning. In FY06 FORT staff produced the symposium proceedings, *Recovery of the Black-footed Ferret: Progress and Continuing Challenges*. In one comprehensive, citable report, this document provides new knowledge generated from the past 15 years of management and research activities and supplies the FWS with critical information for updating and planning future ferret recovery efforts.



Development of Genetic Techniques. At the Rocky Mountain Center for Conservation Genetics and Systematics, a collaborative facility located at the University of Denver (DU), FORT and DU scientists execute molecular studies of conservation genetics and systematics to help managers conserve species of Federal concern. In FY2006, FORT work focused on the following species: ***Mountain Plover***. This year 15 microsatellites from Mountain Plover were isolated and primers developed for those microsatellite loci. Scientists used these markers to genotype individuals from 4 breeding locations of Mountain Plover in an attempt to provide further information about gene flow among populations and levels of genetic diversity. Managers need this information to address questions of gene flow, genetic diversity, and genetic relatedness among populations. Manuscripts describing the molecular markers for this species and reporting the results of the population study are in process. ***Gunnison Sage-Grouse Population Estimation Using Fecal DNA***. Center researchers continue to optimize extraction techniques to determine whether this is a feasible option for mark-recapture studies. They are also developing new markers specifically from Gunnison Sage-Grouse for use with low-quantity and -quality DNA samples. This work is supported by the Colorado Division of Wildlife and the University of Denver's Partners in Scholarship program. ***Indiana Bat***. A pilot study was completed showing that DNA can successfully be extracted from single Indiana bat fecal pellets collected from beneath roost trees. Additionally, researchers isolated and developed primers for a suite of highly polymorphic microsatellite loci that can be used 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.

Population Genetics of Gunnison Sage-Grouse: Implications for Management. The newly described Gunnison Sage-Grouse is a species of concern for management because of marked declines in distribution and abundance. Loss and fragmentation of sagebrush habitat have also caused remaining populations to be unusually small and isolated, and therefore genetically at risk. In collaboration with the Colorado Division of Wildlife and scientists at the University of Denver, FORT recently completed a range-wide DNA analysis of Gunnison Sage-Grouse populations. These data were used to assess the extent of population subdivision among Gunnison Sage-Grouse populations and to document levels of genetic diversity. The study provided data for a range-wide

conservation plan for this bird, including information pertaining to monitoring and maintaining genetic diversity.

Shorebird Ecology on U.S. National Wildlife Refuges. The U.S. Fish and Wildlife Service conducts surveys of migratory birds, including shorebirds, at individual refuges in the National Wildlife Refuge system. Conducting accurate counts is difficult, especially at migration stopovers where (1) only a portion of the population is present at any one time, (2) different species and sexes have different migration chronologies, and (3) habitat availability and bird numbers vary considerably from year to year. Furthermore, there are no established sampling protocols that address these complicating factors at migration stopovers. FORT scientists have been working with USFWS scientists at the Squaw Creek National Wildlife Refuge in Northwestern Missouri to develop



protocols for producing better estimates of the number of migrating shorebirds that use refuges during spring and fall migration. This published work is receiving attention because the developed protocols generally can be applied to other species in other areas needing accurate estimates of migrating birds. The recently completed work has also been used to support a recommendation for designating the Squaw Creek National Wildlife Refuge as a site in the Western Hemisphere Shorebird Reserve Network, administered by the Manomet Center for Conservation Sciences.

Estimating Effects of Ecological Limiting Factors with Quantile Regression. Accurate understanding of organism responses to changes in their environment and useful predictions for management decisions require comprehensive modeling of heterogeneous statistical variation. FORT specialists expanded their applications and statistical expertise with quantile regression, a flexible method for modeling all parts (conditional quantiles) of heterogeneous response distributions that requires minimal assumptions. Published applications of quantile regression included modeling redband trout habitat for the U.S. Bureau of Land Management and salt marsh plant biomass response to environmental stressors done with the Coastal Ecology Institute, Louisiana State University. Two statistical papers were published on alternative permutation testing procedures for linear quantile regression that provide improved inference procedures for many ecological applications. These testing methods were implemented in the FORT-developed Blossom statistical package (<http://www.fort.usgs.gov/Products/Software/blossom/>). An invited talk on ecological applications of quantile regression and linear model permutation procedures was given at an international statistical workshop on quantile regression held in Scotland.

A Quantile Count Model of Cape Sable Seaside Sparrow Response to Water Depths in the Everglades. The quantile count regression model is a new statistical alternative for surveying rare and endangered species. In FY06, a publication was drafted and a presentation made at the Ecological Society of America annual meeting on employing this model to assess responses of the endangered Cape Sable Seaside Sparrow to water depths and occupancy history in Everglades National Park. The model used data the National Park Service collected annually from 1992 to 2005 in extensive surveys of breeding sparrow populations. Our quantile count model estimates indicated substantial decline in the upper 50th percentiles of Cape Sable Seaside Sparrow counts as water

depths increased from 0 (1–6 birds) to 20 cm (0–1 bird) for sites occupied by sparrows in prior years, and no decline in the upper 10th percentiles of counts (1 bird) for sites without sparrow occupancy in prior years. Our model provides a new quantitative description indicating a rapid decline in, but not complete elimination of, Cape Sable Seaside Sparrow breeding habitat as water depths increase to more than 15 cm.

Sharing the Wealth: Access to Expertise

Besides research, FORT scientists work with partners to problem-solve and share expertise, sometimes working on common natural resource issues across borders. Largely these take the form of workshops, training, and educational and other partnerships involving professional exchange and degree work. Following are some highlights from 2006.

Workshops



Wyoming Landscape Conservation Initiative. Southwest Wyoming possesses major energy resources as well as significant blocks of public land featuring world-class wildlife species and habitats. Accelerating energy and other human developments could have significant impact on these wildlife resources. To ensure full consideration and adaptive management of Wyoming's wildlife and habitats in the face of these increasing land-use pressures, the U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, Wyoming Game and Fish Department, USDA Forest Service, and USGS are developing the *Wyoming Landscape Conservation Initiative* (WLCI). The WLCI is a long-term, science-based collaboration designed to assess and enhance aquatic and terrestrial habitats at a landscape scale while facilitating responsible energy development. The initiative already has been recognized for partial funding under the Department of the Interior's FY 2008 American Landscape Initiative for Healthy Lands, Communities, and Economies. In September 2006, FORT hosted a meeting of the partners (including FORT staff) to develop a strategy based on research priorities and infrastructure needs. Because of its ample energy resources, prime wildlife habitat, and number of at-risk species, Southwest Wyoming serves as an ideal laboratory for developing new approaches to landscape conservation. As such, this region will be the initial focus of the WLCI. If successful, this concept could be applied to other ecosystems anywhere in the country.



Instream Flow Listening Session. Scientific support for complex management decisions involving water use and impacts to aquatic systems requires a better understanding of

critical instream flow and habitat needs. The USGS Central and Western Regions sponsored an instream flow listening session April 18–20 in Fort Collins, Colo., entitled “Tools and Approaches for Decision-making and Resource Management.” Federal natural resource agency managers and scientists discussed information needs as well as approaches for analyzing water requirements related to streamflow and habitat needs for instream aquatic communities. Workshop participants identified key resource management issues, new directions for advancing scientific understanding and support of these issues, and suggested directions for the USGS. Workshop results are provided in USGS Open-File Report 2006-1256.

Travel Management on Public Lands Workshop. In order to make effective land management policies and decisions, public lands managers require information about recreational travel on public lands, including natural and cultural resource impacts, policy and regulation effects, visitor needs and expectations, and techniques for collecting and applying scientific data to these issues. Recreational travel includes trekking on foot (hiking and walking), animal-assisted travel (as with llamas or horses), and motorized off-highway vehicle travel (such as motorcycles, ATVs, or 4-wheel drive vehicles). Off-highway vehicle use on BLM lands alone increased 42 percent from 1999–2004. To help Federal land managers address this issue, FORT social scientist Phadrea Ponds and colleagues organized and hosted a workshop February 21–23, 2006, bringing together research and information about collaborative processes to help build the background for decisions concerning travel management on Federal lands.

NBII All-Nodes Meeting. On October 24–28, 2005, the National Biological Information Infrastructure convened a 5-day information exchange for all of the node coordinators, developers, and partners. The NBII is a collaborative program providing access to high-quality databases, information products, and analytical tools maintained by NBII partners and other contributors on the Nation's biological resources. Sessions included content organization and management, public portal topics, technical issues and innovations, node application and site integration, and node accomplishments. The Southwest Information Node staff, led by FORT scientist Leanne Hanson, hosted the meeting in Albuquerque, N.M., and SWIN was showcased.

Museum Collection Joint Meeting. A joint meeting of the Society for the Preservation of Natural History Collections and the Natural Science Collections Alliance was held May 23–27 in Albuquerque, N.M., to highlight collaborative research efforts related to scientific collections in museums, government organizations, private entities, and international groups. Entitled “The Road to Productive Partnerships,” the meeting offered workshops and sessions on topics relevant to natural history collections and their various partners. FORT scientist and co-host Cindy Ramotnik, who curates the USGS vertebrate collection at the University of New Mexico Museum of Southwestern Biology, coordinated the meeting.



Training

Negotiation Training for Natural Resource Professionals. Natural resource management, involving humans as it does, increasingly demands skills in negotiation to better involve the public in making decisions about trust resources. Based on research they have conducted since the early 1980s, FORT social scientists, in collaboration with the USGS National Training Center, annually offer two courses on natural resource negotiation. The basic course is offered twice each year in Fort Collins, Colo., and elsewhere upon request. The advanced course is offered once each fall in Fort Collins. Both courses teach in-depth natural resource negotiation strategies, skills, and techniques through lecture, hands-on training in real-life negotiation scenarios, evaluation, and discussion. Upon completion, participants are prepared to participate more effectively as members of a negotiating team—and following the advanced course, to develop and lead such a team. Over 50 participants in FY06 courses represented the U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, National Park Service, USDA Forest Service, U.S. Bureau of Land Management, Colorado State University, private organizations, and State agencies in Colorado, New Mexico, and Alaska. Course evaluations, which were highly positive, are used to improve the courses.

Brown Treesnake Rapid-Response Training. The Brown Treesnake (BTS), a destructive invasive species that became established on Guam in the 1940s, has extirpated many indigenous species and causes frequent power outages on the island. To help prevent incursions on other snake-free islands in the Pacific region, USGS established the BTS Rapid Response Team (RRT). With local support and public assistance, the RRT can respond quickly to snake sightings with teams of visual searchers, trained dogs, snake traps, and other tools to capture and remove BTS from snake-free locations. RRT membership and member refresher training is ongoing through yearly workshops. Currently there are more than 40 team members located throughout the Pacific region. All team members participate in intensive training on Guam, where they gain first-hand experience with BTS sighting and control measures, including response protocols, snake capture and handling, visual searching, and trapping techniques. The 20 participants in this year's courses represented the Hawaii Department of Agriculture, Maui Invasive Species Committee, Commonwealth of the Northern Mariana Islands Department of Land and Natural Resources, Palau Division of Agriculture, Federated States of Micronesia Agriculture Unit, Republic of the Marshall Islands Ministry of Resources and Development, and the U.S. Army at Kwajalein Atoll.

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**

Foreign Exchange



Stable Isotopes and Migratory Shorebirds in Argentina. Wildlife Biologist Adrian Farmer has three cooperative relationships with universities in Argentina: the Universidad Nacional de la Patagonia, San Juan Bosco; the Universidad Nacional de Córdoba; and the Universidad Nacional de La Pampa. FORT is providing funding for three students to pursue a Ph.D., an

M.S. degree, and a senior project, respectively. The cooperative research is being conducted between these universities and the USGS Geology and Biological Resources disciplines. The project goal is to evaluate the effectiveness of stable isotopes in identifying the winter location of migratory shorebirds in Argentina and transfer technology and skills to Argentina.

Mapping in Ethiopia. Through a Memorandum of Understanding with The Murulle Foundation—a 501(c)(3) organization committed to conserving the balance between cultural and natural resources in sub-Saharan Africa—FORT IT Specialist Robert Waltermire provided GIS expertise and products for a project involving the ecology and distribution of mountain nyala (a rare antelope) in Ethiopia. Cooperators are submitting a paper on this work to *Mammal Review*.

Fire and Climate Effects in Spain. Valencia. Supported by the Universidad de Alicante and the Valencia regional government, FORT Research Ecologist Craig D. Allen was an invited scholar in Spain, where he participated in field reviews of research on post-fire watershed responses and the effects of drought and desertification on runoff, erosion, vegetation dieback, and ecological restoration. The exchange included the final REACTION (“Restoration Actions to Combat Desertification in the Northern Mediterranean Basin”) workshop in Portugal in October. Later in the year, Dr. Allen reciprocally hosted Dr. Susana Bautista in New Mexico, continuing collaborative work on these research topics. **Granada.** Working with faculty of the Universidad de Granada, Dr. Allen began three collaborations parallel to studies of climate change impacts on western U.S. mountain ecosystems (Western Mountain Initiative; WMI): (1) assessment of climate-induced forest dieback in the mountains of southern Spain, along with Global Change and Mountain Regions Project (Glochamore)-supported initial efforts to develop a proposal for Europe-wide research on montane forest dieback through the 7th Framework Programme of the European Union); (2) ecosystem effects of post-fire forest treatments in the Sierra Nevada National Park (UNESCO Biosphere Reserve in Spain); and (3) discussions on potentially linking the global change research program of the Universidad de Granada (focused on the nearby Sierra Nevada National Park) with the WMI through the National Biological Information Infrastructure’s Southwest Information Node. In April 2006 Dr. Allen spent one week in the Granada region assessing local patterns of forest dieback and working on the park project—involving post-fire forest regeneration and ecological restoration techniques—supported by and in collaboration with the university and the park.

Sharing the Wealth: Access to Information

Much of FORT’s mission involves producing scientific data and information. But FORT staff also package and otherwise make this information accessible to the science community, resource management agencies, and the public in various ways. Some efforts, like GIS mapping work and workshops, are described above. Others, like serving Web-based information, providing meta-data, and developing and sharing information products, are described below.

Information Products and Delivery

In FY06, FORT produced 133 publications and 18 Web application and software products, many of which are available on FORTWeb (<http://www.fort.usgs.gov/products>). Scientists also delivered numerous presentations, seminars, and talks, including at least 40 that were invited and two of which were broadcast on Animal Planet’s *Get Out There!* series. Another approach to informa-

tion delivery involves an ongoing seminar series, entitled *Interactions of Society and the Environment*. This series is jointly sponsored by FORT, the USDA Forest Service Rocky Mountain Research Station, and Colorado State University's Department of Journalism and Technical Communications. FY06 produced 8 seminars held in Fort Collins at CSU or at FORT covering research trends, findings, and needs related to human dimensions and natural resources. Topics in 2006 included public involvement, conservation practices on agricultural lands, wildland-urban interface issues, social science issues surrounding wildfire events, and unmanaged recreation/off-highway travel on public lands.

Web Site (FORTWeb)

FORTWeb (<http://www.fort.usgs.gov>) underwent its first complete revision in nearly five years, featuring a new look (upgrading to new USGS templates), greater functionality, and more science content. In addition, the conversion of all existing FORTWeb databases to Microsoft's SQL Server has improved performance, security, and management of all FORTWeb's information and products. FORTWeb continues to provide visitors with a broad range of information about FORT research, and it is integral to the development and delivery of a variety of products to USGS customers. FORT products, which include software, publications, presentations, and data (<http://www.fort.usgs.gov/products>), accounted for approximately 20 percent of FORTWeb customer visits. Ten new full-text publications were created for distribution via FORTWeb in FY06, bringing the total of full-text publications available online to 208. While most products target FORT's technical and scientific audience, FORTWeb communications and outreach products such as News Highlights (<http://www.fort.usgs.gov/news>) and Science Features (<http://www.fort.usgs.gov/resources>) target the general public and non-technical customers. These information products generated approximately 65 percent of all FORTWeb visits in FY06. FORT staff produced and served 17 News Highlights, a new Negotiation Training Web site, 5 Research Briefs, and 2 Research Spotlights in FY06.

Metadata

Metadata serves several important roles in managing information. A metadata record is a file of information that captures the basic characteristics of a data or information resource, including publications. Metadata documents, organizes, and maintains accessible information about research projects, datasets, and scientific publications that help people who use these data locate the data they need (whether produced by themselves or others) and determine how best to use it. Because the generators of the data (e.g., scientists) move on over time, metadata also preserves the data history so that datasets can be re-used or adapted as needed. The Federal Geographic Data Committee (FGDC) requires the application of metadata standards to all federally served metadata. The standards provide a common set of terminology and definitions for the documentation of data,

The screenshot shows the Fort Collins Science Center website. At the top is the USGS logo with the tagline "science for a changing world". Below the logo is a navigation bar with links for "FORT Home", "About", "Science", "Products", and "News & Events". A secondary navigation bar indicates "You are here: FORT". The main content area is titled "Welcome to the Fort Collins Science Center" and includes a mission statement: "...Developing and disseminating science-based information and tools needed for understanding the Nation's biological resources in support of effective decision making." Below this are several sections: "Learn more about the Fort Collins Science Center", "Fort Collins Science Center 2005 Accomplishments (PDF)", and "Driving directions". The "In the News" section features a headline "FORT Scientist Receives NPS Regional Award" and a photo of a scientist. The "Science Feature" section is titled "Godwits on the Go" and includes a photo of a bird. The "Science Priorities" section lists various research areas like "Aquatic Systems & Technology Applications" and "Ecosystem Dynamics". There is also a "New Online Publications" section with links to various reports and manuals. A "Click here to learn more!" button is visible on the right side.

including items such as title, geographic area covered, dates, data quality, spatial reference used, and contact information. FORT not only produces metadata for its own research and publications, but also serves as a national contact for quality control of metadata for the Web-based National Biological Information Infrastructure (NBII) Principal Node. All FORT metadata is available on the NBII Web site at <http://nbii.gov>.

FORT Metadata. In FY06, FORT created and served approximately 202 new, non-publication, project-overview metadata records and 25 new non-publication theme/dataset metadata records on the NBII Clearinghouse Principal Node. All existing publications metadata records were updated and new records created for a total of 2013 publication metadata records. Publications metadata were served in the NBII Clearinghouse Bibliographic Node. FORT developed a database tool that uses information extracted from the USGS project database to create a significant portion of the non-publication overview metadata. FORT specialists employ this same tool to begin development of the detailed non-publication, theme/dataset metadata, which is then supplemented by information provided by the principal investigators. Metadata staff also refined and enhanced previously developed tools to more efficiently produce the publications metadata.

NBII Metadata Quality Control. In support of the NBII, FORT in FY06 served as the national contact for quality control of metadata files submitted by numerous public and private data providers for serving on the NBII Clearinghouse Principal Node. FORT staff also reviewed files submitted to be served on other nodes. Files were reviewed for the quality of content as well as syntax and conformance to the FGDC Content Standard and Biological Data Profile. Following review, FORT staff provided feedback and enhanced files to many submitters to address missing information or errors and to improve understanding of requirements for better conformance in subsequent submissions. By the end of FY06, FORT reviewed 587 submissions and resubmissions; of those, 497 metadata files were completed and served on various NBII nodes.

The Future Is Now

New Science Initiative: Energy and Land Use Research and Technical Assistance

Exploration and development of domestic oil and gas resources have become a national priority, yet our understanding of the direct and indirect effects of energy development on surrounding



ecosystems remains limited. This poses a challenge for natural resource managers, who are balancing priorities that include maintaining healthy rangelands and wildlife habitat while providing for resource development and multiple public uses. In a major new thrust, FORT and several other USGS science centers, along with Federal, State, and local partners, are jointly conducting an interdisciplinary research program focusing on these issues at a regional landscape level in the western United States. This interdisciplinary work will contribute directly to the *Wyoming Landscape Conservation Initiative*

(*WLCI*), a long-term, landscape-scale, science-based collaboration to ensure full consideration and adaptive management of Wyoming's wildlife and habitats in the face of increasing land-use pressures in Wyoming. Research projects for 2007 will investigate diverse, multi-disciplinary energy and land-use issues, including efforts to assess sagebrush habitat conditions; identify and evaluate the ecological impacts of fire, grazing, and off-highway vehicle use on sagebrush ecosystems; quantify the effects of road use on ungulates; refine scientific understanding of sage-grouse population dynamics and genetics; and evaluate and centralize sagebrush ecosystem Internet resources. Several projects led by FORT that were active, expanded, or commenced in FY06 are supporting this new initiative, and include the following:

Developing a Regional Approach for Integrated Monitoring Related to Energy Exploration and Development: Colorado Pilot Study. The U.S. Bureau of Land Management faces a difficult task in developing and implementing monitoring programs that are effective and efficient across different geographic and time scales. Further, such programs must be capable of satisfying multiple institutional and legal requirements associated with environmental compliance and land-use planning. To this end, FORT and BLM are developing a practical approach to integrated monitoring related to energy development that capitalizes on existing monitoring programs and readily available data and information. This effort is part of a national focus on monitoring by BLM and is one of three pilot studies being conducted, with the other two projects occurring in Wyoming and Alaska.

Evaluating Species Models for the Ecoregional Analysis of Sagebrush Ecosystems within the Wyoming Basin. Ecoregional assessments are valuable predictive tools for addressing large-scale, range-wide factors likely to affect the well-being of species of concern, and they can guide the development of management plans to reduce further loss or degradation of included habitats. In this task, FORT scientists will (1) develop spatially explicit models for 5 additional sagebrush-dependent species occurring across the Wyoming Basin Ecoregional Assessment Study Area, (2) conduct field surveys to sample the distribution of species of concern in relation to habitat and disturbance, and (3) use field data to assess the accuracy of all 10 different species models, update the model parameters, identify regions of significant impact by land use, and test the response of species to human disturbance.



Mapping Sagebrush Habitats in Human-Influenced Landscapes. The BLM, which manages approximately 50 percent of remaining sagebrush habitats, needs methodologies to accurately assess and monitor habitats at landscape scales to meet management objectives. Scientists involved with this task are developing statistically rigorous methods to map the distribution, cover, and height of sagebrush as well as identify the distribution of roads, trails, and oil and gas infrastructure. In part this work involves testing the relative effectiveness of different remote sensing technologies in identifying and mapping various sagebrush species at larger scales using ground-truthed vegetation data. During the summer of 2006, researchers compiled all existing remotely sensed and digital data and acquired additional remotely sensed imagery at sites across the range of sagebrush habitat within Wyoming. They also began mapping anthropogenic features in southwestern Wyoming, using existing and newly acquired digital data.



Quantifying the Physical Impacts of Reenacted Mormon Handcart Journeys across the Historic Oregon-California Trail.

In 1843, a train of wagons and people began their journey to the new frontier, traveling from Missouri across parts of Wyoming along the only corridor that provided access to Oregon, Idaho, Washington, California, and Nevada. Over the next 25 years, as many as half a million people made this historic journey along the Oregon-California



Trail. The trail was still used into the early 1900s, although to a lesser extent. In 1998, Mormon handcart companies began reenacting their ancestors' historic westward trips, resulting in short-duration but intense use of certain sections of the trail. Because this trail is considered a historic relic, BLM managers are concerned about damage to the trail caused by the intense use of wagons, handcarts, and motorized vehicles during these reenactments, as well as other off-highway vehicle use. FORT scientists are quantifying those impacts by (1) compiling all existing remotely sensed, digital, and air-photo data of the study area and (2) working with BLM field staff to compare the number, duration, and types of users along various segments of the trail in order to assess the impacts of each type of use and of combined uses. Managers will use these data to derive scientifically defensible "thresholds of use" that will allow this stretch of historic trail to remain relatively intact.

Assessing Grazing Treatments on Vegetation and Wildlife Communities across Managed Burns and Habitat Controls. Two tools that the BLM can apply to manage shrub-steppe ecosystems are grazing and burning. However, information is limited on the appropriate timing and levels of grazing in these fragile systems for suitable recovery and establishment of vegetation communities, particularly after natural or prescribed burns. Beginning in 2004, FORT and the BLM Rawlins Field Office began a cooperative effort to re-establish the Stratton Sagebrush Ecological Study Site as a long-term research location. Stratton is the only high-elevation sagebrush research site of its kind, with a rich 30+ year history of research and baseline data. FORT researchers will assist BLM managers in understanding the effects of grazing and burning by assessing wildlife responses to treatments. Within each grazing and burn treatment site and control site, scientists are (1) quantifying Greater Sage-Grouse, songbird, and small mammal abundance and habitat use/association; (2) evaluating changes in presence and abundance of particular wildlife species over the past 30 years at Stratton to determine how current management practices (grazing and burning) are affecting wildlife populations in a sagebrush ecosystem; and (3) continuing long-term research assessments to evaluate changes in the vegetation community and wildlife associations as they relate to BLM adaptive-management activities and research. In FY06 FORT scientists developed a habitat-based stratified sampling design, setting up sampling across grazing treatments, controls, and burned sites. Field staff conducted vegetation measurement, breeding bird surveys, Sage-Grouse transect surveys, and small mammal trapping.

New Science Directions: Strategic Planning

In FY06, FORT personnel developed a new strategic direction to address a variety of administrative and other changes that recently have occurred at the national, regional, and Center levels and reflect the changing needs of the DOI agencies it serves.

In the next five years, FORT will identify approximately 20 science focus areas organized within these five branches: Ecosystem Dynamics, Information Science, Invasive Species Science, Policy Analysis and Science Assistance, and Trust Species and Habitats.³ Each focus area will be led by a Senior Investigator and will involve one or more projects with associated Project Chiefs. Some of the major goals include the following:

- Maintain and further develop the scientific capacity to understand, predict, and address complex biological change on landscapes in support of DOI natural resource management objectives.
- Promote science-based Federal resource management decisions and adaptive management strategies through the use of long-term, geographically focused research and monitoring on Federal lands to advance ecosystem science and understanding related to causes and consequences of introduced and natural changes.
- Provide natural resource managers with credible science-based information on the interrelationships among the physical, chemical, aquatic, and biological components of natural systems for resource management decision making.
- Conduct cutting-edge research on monitoring, ecology, habitat requirements, distribution and abundance, reintroduction and restoration techniques, and genetics and systematics involving species and habitats held in the public trust.
- Establish the National Institute for Invasive Species Science as the lead invasive species unit for DOI by providing state-of-the-art research and technical assistance related to invasive species management concerns, including understanding how these species are introduced, identifying vulnerable areas, forecasting invasions, and developing effective prevention, control, and restoration methods.
- Exercise Bureau leadership in the integration of biological, social, economic, and institutional information and analyses of conservation policies and management practices, providing resource management agencies with a more comprehensive basis for making effective management and conservation decisions.
- Provide Bureau leadership in information technology, management, integration, and synthesis, and in delivery of scientific information and products.

In order to address these goals, FORT expertise in wildlife biology and ecology will expand to reflect the Center's new strategic directions of (1) conducting integrated and multidisciplinary inventorying, monitoring, and research to obtain a scientific understanding of complex ecological systems and landscapes; and (2) using these understandings to develop models and forecasting systems that support natural resource decision makers. These new directions call for additional expertise in areas such as genomics, inventory and monitoring design, hydroecology, restoration ecology, landscape ecology, systems analysis, and ecological systems modeling. In the true spirit of adaptive management, FORT managers, scientists, and science support staff are reconfiguring their talents and capabilities to best meet the complex and evolving needs of natural resource managers nationwide.

³ Staff and work formerly under the Aquatic Systems and Technology Applications Branch, active in 2006, will be divided among the latter five branches. A new branch, Information Science, incorporates Web and other technology applications, GIS and remote sensing, modeling, and information management and delivery.