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FORT COLLINS SCIENCE CENTER

Who We Are and What We Do

The U.S. Geological Survey's Fort Collins Science Center (FORT) is one of 17 USGS biological science centers.

FORT conducts research and develops technical applications to assist land managers in understanding and managing biological resources, habitats, and ecosystems. The majority of FORT's activities are conducted within the 15-state Central Region of the USGS. However, many FORT projects are national or international in scope.

FORT serves all Department of the Interior land management bureaus and other natural resource agencies. In addition, FORT scientists partner with DOI and other Federal entities such as CDC, DOE, EPA, NASA, NIH, and USDA to share expertise and resources. FORT also partners with several universities and works cooperatively with states and nongovernmental organizations.

FORT scientists produce reports and publications, predictive models and software, maps and GIS products, and other technical assistance in the form of meetings, workshops, training, field visits, and needs assessments.

How We Operate

FORT conducts its science with a staff of more than 110 Federal employees and a support services contract of more than 40 professionals. Most staff are based at the headquarters in Fort Collins. To facilitate collaborative science, FORT scientists are also collocated at the Natural Resource Ecology Laboratory at Colorado State University; the new Center for Conservation Genetics and Systematics at the University of Denver; the Arid Lands Field Station at the University of New Mexico; the Jemez Mountains Field Station at Bandelier National Monument; and the Bureau of Reclamation's Technical Services Center in Denver.

How We're Organized

FORT is organized around six major Science Programs. Interdisciplinary project teams integrate research across these six Science Program areas:

Aquatic Systems and Technology Applications

FORT scientists develop and adapt technology to address a range of natural resource issues and provide biological information that is relevant and usable. FORT staff have state-of-the-art expertise in Unix- and Windows-based information systems, satellite image processing, satellite telemetry of wildlife, hydraulics, sediment transport, water quality, aquatic habitat modeling, GIS, decision support systems, web-based applications, and basic ecology.

Working with natural resource managers, FORT scientists have developed applications for such issues as river systems management, reservoir operations, constructed wetlands, environmental contaminants, international wildlife policy, endangered species, and economic valuation of natural resources. FORT also leads development of the National Biological Information Infrastructure (NBII) Southwest Information Node to help address that region's complex environmental issues.

Ecosystem Dynamics

Many challenging natural resource management issues require consideration of a web of interactions among ecosystem components. Essentially ecosystem problems, their spatial and temporal complexity demands an interdisciplinary approach integrating biotic and abiotic processes. FORT provides information for Federal resource managers and uses long-term, place-focused research and monitoring on Federal lands to advance ecosystem science.

Current studies fall into five general areas. *Fire Science* focuses on the effects of fire on plant and animal communities at multiple scales, and on the interactions between post-fire vegetation, runoff, and erosion processes. *Riparian Ecology* is concerned with interactions among streamflow, fluvial geomorphology, and riparian vegetation. *Herbivore-Ecosystem Interaction*s involves quantifying the factors regulating herbivore populations and cascading effects through predator-herbivore-plant-soil linkages. *Reference Ecosystems* entails long-term, place-based studies of ecosystem biogeochemistry. Finally, *Integrated Assessments* is investigating how to synthesize multiple stressors and response variables over complex landscapes in ways that are useful for management and planning.

International Center for Applied Ecology

Restoring and preserving natural systems globally depends increasingly on exchanging knowledge and expertise across nations. FORT brings scientists from other countries to the USGS to build experience, share expertise, and generate a Federal scientist network for use in this country and by countries of guest scientists. FORT scientists also offer technical assistance and training in cooperating countries. Projects have involved neotropical migratory birds and bats in the Western Hemisphere, sustainable economic development and conservation in China, snow leopard and red-crowned crane conservation in Asia, and several comparative ecology studies involving invasive plants, plague, and the endangered black-footed ferret. FORT is also testing ways of sharing information and methodologies remotely.

Invasive Species Science

Non-native species of plants, animals, and other organisms negatively affect the ecosystems they enter, with an estimated economic impact in the U.S. of over $130 billion per year. The program's goal is to provide science and technical assistance relating to invasive species management concerns, from how these species are introduced to identifying areas vulnerable to invasion.

FORT houses the National Institute of Invasive Species Science, a consortium of partnerships established by the USGS and its cooperators. Through FORT, the Institute is developing the Invasive Species Information Node of the NBII, a comprehensive, accessible database of information about invasive plants, animals, and disease agents. From these data, and in partnership with Colorado State University (CSU), the CSU Natural Resource Ecology Laboratory, and NASA, FORT scientists are developing models to understand and predict invasive species distributions for more effective management. FORT researchers also are testing prevention and intervention techniques for the brown treesnake, which has extirpated many native species on Guam and threatens indigenous species on other Pacific islands.

Policy Analysis and Science Assistance

Most resource management decisions involve the integrated use of biological, sociological, and economic information. Combining this information provides a more comprehensive basis for making effective land management and conservation decisions. Toward this end, FORT scientists contribute expert knowledge by conducting biological, social, economic, and institutional analyses of conservation policies and management practices. This information helps land managers and other decision makers in their efforts to meet competing resource demands in water resources projects, site-specific land management plans, and regional ecosystem management programs. These integrated science activities have included evaluating national conservation policies, regional economic trends, and wildlife management policies. FORT scientists also assist decision makers by helping to resolve resource management conflicts through stakeholder and institutional analyses.

Species and Habitats of Federal Interest

Ecosystem changes directly impact a wide variety of individual plant and animal species, native floral and faunal communities, and groups of species such as amphibians and grassland birds. Many species are dependent on suitable management of public lands to prevent listing under the Endangered Species Act or for recovery from endangered status.

FORT conducts research on the ecology, habitat requirements, distribution and abundance, and genetics of many such species, including black-footed ferrets, migratory and grassland birds, bats, boreal toads, and prairie dogs. Scientists also develop reintroduction and restoration techniques as well as technologies for monitoring populations and analyzing data.

Where We're Located

The Fort Collins Science Center headquarters is located on the Natural Resources Research Center (NRRC) campus. The NRRC was established to support and enhance cooperative research on natural resource issues. It is a partnership of six Federal agencies from the Departments of Agriculture and the Interior, the U.S. General Services Administration, and Colorado State University. When finished in 2004, the campus will consist of six buildings housing more than 1200 natural resource professionals.

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FORT COLLINS SCIENCE CENTER
AQUATIC SYSTEMS AND TECHNOLOGY APPLICATIONS

CAPABILITIES

Land and water management agencies are responsible for restoring and conserving our nation's natural resources. However, they face increasing, often competing demands for those resources, which can result in alteration or loss of critical riverine, riparian, wetland, and terrestrial habitats. Land and resource managers may be in federal, state, or local government, but all have the same need for quantitative, objective, science-based information that helps them plan, manage, and conserve the natural resources within their purview.

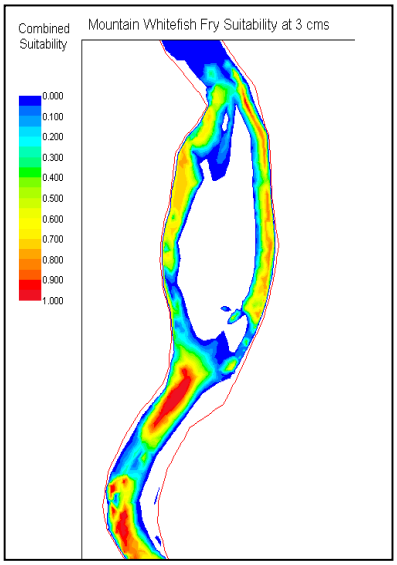
The Aquatic Systems and Technology Applications Program (ASTA) of the Fort Collins Science Center (FORT) encompasses a wide variety of studies, investigations, and activities that are related to providing tools and capabilities for natural resource managers. ASTA's mission is to provide managers with credible science-based information on the interrelationships among the physical, chemical, aquatic, and biological natural resources in river basins for resource management decision-making.

Program goals are to:

- develop and apply specific models and analysis tools for resource management issues;
- identify habitat and biological linkages in river corridor environments;
- design and evaluate specific water quality improvement features;
- define economic measures for natural resource benefits;
- investigate altered flow regime effects on native fish populations;
- characterize sediment transport effects in river corridor environments; and
- utilize advanced technology to evaluate landscape-scale changes in river basins.

SELECTED PROJECTS

Five major project areas support the ASTA mission and goals for resource management: (1) river and stream modeling and decision support systems, (2) western freshwater and anadromous fish, (3) lake and wetland ecosystems: constructed wetlands, (4) fish disease and sediment transport modeling, and (5) technology applications in support of Department of the Interior agencies. Representative projects from each area are described below.

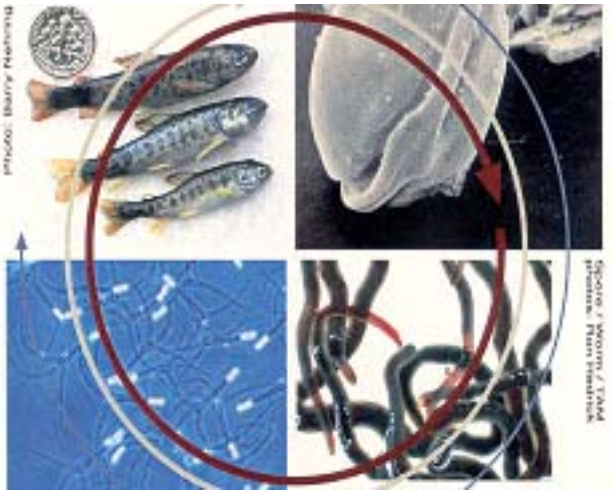


River and Stream Modeling and Decision Support Systems. This project focuses on developing one- and two-dimensional aquatic habitat models, refining hydrodynamic models for habitat issues, building computer tools for habitat research, providing science-based information for regulated river systems, and developing planning and assessment models to evaluate water management strategies. Changes in river flows cause temporal and spatial variability in habitat for aquatic organisms. Visual representations of this variability provide resource managers with more explicit information on what is required to maintain or improve river conditions for target species, for example, in the Upper Yellowstone River in Montana and the Klamath River Basin, Oregon and California. Decision support systems provide a central location for data, provide institutional memory for resource managers, and allow "gaming" with river systems to optimize or improve certain resource variables.

Western Freshwater and Anadromous Fish. Project scientists investigate and examine fish community relationships in lakes and rivers, using both traditional and new technologies. Spatial scales range from small streams to large reservoirs. Methods employed in this project range from standard gill netting and electrofishing to sophisticated hydroacoustic sonar, geographic information systems (GIS), tracking telemetry, and other remote sensing techniques. Both recreational and special status species research are a part of this work. For example, studies being conducted on the Colorado River and associated reservoirs will benefit restoration efforts for endangered fish species and assist the Bureau of Reclamation in developing water project operating plans. In other work, investigations of predator/prey interactions utilize laboratory testing, underwater videography, and stable isotope analysis.

Lake and Wetland Ecosystems: Constructed Wetlands. In the arid West, loss of critical wetland and riparian habitat due to depletion of water resources has severe impacts on biodiversity. Often the only water available for restoring wetland or riparian habitat is of impaired quality. Using constructed wetlands as low-cost, low-maintenance, socially attractive treatment systems provides an opportunity to reuse impaired source water while enhancing wildlife habitat. ASTA scientists are applying an ecosystem perspective to understanding water treatment functions, evaluating the habitat created, and developing cost-effective techniques for operation and maintenance of these wetlands. Research is designed to understand water treatment functions within constructed wetlands, evaluate wildlife habitat, improve the integration of habitat value and treatment function, develop cost-effective techniques for habitat management, and apply new techniques to the restoration of degraded natural riparian and wetland ecosystems. Technical assistance in design, operation, and maintenance of constructed wetlands is provided to client agencies in many western states.

Fish Disease and Sediment Transport Modeling. The goal of this project is to link sediment/channel interactions with changes in physical habitat important to fish populations. ASTA scientists are determining sediment limiting factors for *Tubifex* species, an intermediate host for whirling disease, using statistical routines developed at FORT to predict spatial distribution of sediment size classes with one-, two-, and three-dimensional models. The studies of sediment and channel interaction develop predictions for channel maintenance flows, flows to remove (or not remove) sand and fines, and flows to predict spawning gravel movement. For example, ASTA scientists are using sediment transport modeling to identify specific places in river channels modified by construction activities that could be redesigned to reduce the area and suitability of sediment deposits for *Tubifex* species to survive.



Technology Applications in Support of Department of the Interior (DOI) Agencies. The Technology Applications Project Team (TAT) conducts applied research and development to help DOI agencies and international conservation organizations better understand and manage natural resources. TAT's cadre of highly skilled information technology specialists and ecologists work for sister DOI bureaus, building Web-based applications and testing promising new technology. Major efforts in the past several years have involved converting operational programs into Web applications that vastly improve access and efficiency. For example, TAT built and maintains a suite of programs on the Web for the U.S. Fish and Wildlife Service (USFWS) that provides agency and public access to critical data such as endangered species, wetlands, and critical habitat. This program is accessed daily by hundreds of registered USFWS users and thousands of public users, processing more than three million database transactions per month. Other products under development include a comprehensive research reporting system for the National Park Service, an air quality monitoring system for the Bureau of Land Management in Wyoming, and the Southwest Information Node of the National Biological Information Infrastructure (NBII).

STAFF

Science Director: **David Hamilton**
Ph.D. Ecologist: wetland ecology and management, computer applications.

Bartholow, John, M.S. Ecologist: temperature, water quality, and fish population modeling; systems analysis; training.

Bovee, Ken, M.S. Hydrologist: stream habitat analysis, hydraulic modeling, hydrology.

Campbell, Sharon, M.S. Aquatic Ecologist: reservoir and stream ecology, water quality.

Carpenter, Jeanette, Ph.D. Fishery Biologist: stream ecology, endangered species, introduced species, fish habitat analysis.

Douglas, Aaron, Ph.D. Economist: nonmarket valuation, riverine resources.

Flug, Marshall, Ph.D., P.E. Research Hydrologist: reservoir operations, water resource systems, environmental decision support, modeling and simulation.

Henriksen, Jim, B.S. Ecologist: stream ecology, instream flow, stream habitat analysis, hydraulic modeling, impact analysis.

Hunter, Don, Ph.D. Ecologist: ecology, international conservation, information systems.

Milhous, Bob, Ph.D., P.E. Hydrologist: hydraulic modeling, instream flow models, sediment transport, channel dynamics.

Mueller, Gordon, M.S. Research Fishery Biologist: reservoir fisheries, fish detection, telemetry, sampling equipment, hydroacoustics**.**

Sartoris, Jim, M.S., P.E. Civil Engineer: engineering limnology, water quality, aquatic ecology, wetland creation.

Terrell, James, M.S. Fish and Wildlife Biologist: modeling fish and wildlife habitat relations.

Thullen, Joan, M.B.A., B.S. Botanist: aquatic plant ecology and management, wetland creation, wetland ecology, water quality.

Waddle, Terry, Ph.D. Hydrologist: reservoir operations and water routing models, river hydraulics.

Williamson, Sam, Ph.D. Ecologist: fish population dynamics, cumulative impacts, systems analysis.

Contractor staff provide expertise in the areas of Web-based applications, database development, information technology, GIS, and remote sensing.

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Learn more about the Aquatic Systems and Technology Applications Program at http://www.fort.usgs.gov/research/500/500.asp

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FORT COLLINS SCIENCE CENTER
ECOSYSTEM DYNAMICS

CAPABILITIES

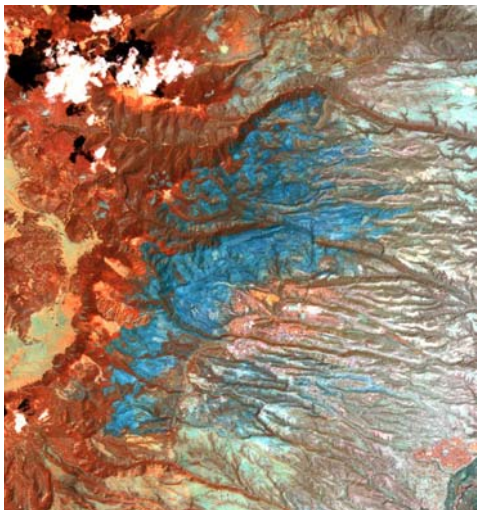
Many challenging natural resource management issues require consideration of a web of interactions among ecosystem components. Essentially ecosystem problems, the spatial and temporal complexity of these issues demands an interdisciplinary approach integrating biotic and abiotic processes. The goals of the Ecosystem Dynamics Program are to inform federal resource management decisions and use long-term, place-focused research and monitoring on federal lands to advance ecosystem science.

Current studies fall into five general areas. Herbivore-Ecosystem Interactions examines the efficacy of multiple controls on selected herbivore populations and cascading effects through predator-herbivore-plant-soil linkages. Riparian Ecology is concerned with interactions among streamflow, fluvial geomorphology, and riparian vegetation. Integrated Fire Science focuses on the effects of fire on plant and animal communities at multiple scales, and on the interactions between post-fire plant, runoff, and erosion processes. Reference Ecosystems comprises long-term, place-based studies of ecosystem biogeochemistry. Finally, Integrated Assessments is investigating how to synthesize multiple ecosystem stressors and responses over complex landscapes in ways that are useful for management and planning.

SELECTED PROJECTS

Herbivore-Ecosystem Interactions. The problem of “overabundance” applies both to elk and to wild horses and burros on federal lands throughout the western U.S. How many ungulates is "too many" is a question for many national parks and other federal lands. Scientists at the Fort Collins Science Center (FORT) have conducted studies in Grand Teton, Yellowstone, and Rocky Mountain National Parks to evaluate the effects of elk herbivory on vegetation communities and nitrogen processes. Similarly, the Bureau of Land Management (BLM) oversees thousands of wild horses and burros on millions of acres, and is responsible for managing and monitoring these ever-growing herds. To help the BLM achieve greater science-based management, FORT scientists coordinated expert input on five key management topics: fertility control, genetic conservation, population dynamics, habitat assessments, and health and handling concerns. With this input, FORT scientists developed a long-range strategic research plan for the BLM, incorporating BLM goals for wild horse and burro management.

Riparian Ecology. Riparian ecosystems in the arid West support large and diverse communities of plants and animals, improve water quality, attenuate floods, and provide recreational opportunities. However, the dependence of riparian systems on streamflow and their desirability for a number of human activities and uses make them vulnerable to human impacts. FORT scientists are studying the factors that generate change in riparian systems to improve the scientific basis for management decisions. For example, relations between river hydrology and the distribution and abundance of riparian plant and animal species are being quantified at multiple sites in the Upper Colorado, Missouri, and Bill Williams river systems so that water resource managers can better understand the consequences of different flow scenarios. Other riparian research studies at FORT are addressing the role of vegetation in mediating flows of water and sediment, and the responses of riparian vegetation to dam removal and alluvial groundwater decline.

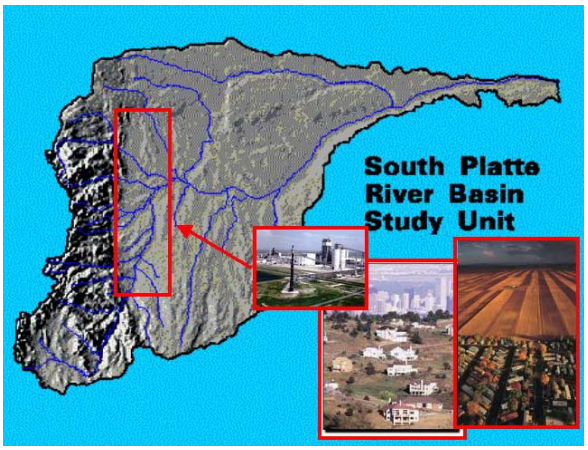


Integrated Fire Science. Fire affects many biotic and abiotic components of ecosystems, in addition to its substantial economic and social ramifications. Although the ecological importance of fire is widely accepted, sound fire management requires greater understanding of the effects of fire on public lands. FORT scientists are leading a team of experts in ecology, hydrology, geology, and social science in a multidisciplinary research effort on wildland fire effects in the Rocky Mountain West. This team is investigating the use of remote sensing data to compare pre- and post-fire effects on avian communities, plant communities, nonnative plant invasion, erosion, and debris flow to learn how fire severity is affected by various fire management practices. Field data are being used to assess the efficacy of Landsat images. Social science incorporates how people living in communities affected by recent fires view fire management. This interdisciplinary approach will help managers integrate and evaluate the trade-offs among different fire management policies and practices, including prescribed fire, non-fire treatments, fire management in the wildland-urban interface, and post-fire rehabilitation and restoration.

Reference Ecosystems. Understanding the long-term effects of change helps managers anticipate and plan for change in both their short- and long-term resource management decisions. Over the decades,

USGS scientists have developed a reference ecosystem network comprising sites protected from changes in local land use. They are located on national park and national forest lands from the Arctic to South Texas, and from the mountains of North Carolina to the Olympic Coast in Washington. Basic ecosystem study is conducted on each to assess the long-term effects of global change, especially from climate and atmospheric contaminant inputs. Owing to the long-term, ecosystem-level research design, the studies provide a unique perspective on the effects of human activity on natural areas. In a similar vein, FORT scientists staffing the Jemez Mountains Field Station are permanently sta-

tioned at Bandelier National Park, New Mexico, where they offer an on-site, place-based approach to science. The scientists design, conduct, and oversee long-term, landscape-scale research and monitoring activities for Bandelier and surrounding wildland areas.



Integrated Assessments. Covering about one-fifth of the state of Colorado, the South Platte Basin includes a vast diversity of landscapes: extensive national forests and parks along the Continental Divide in the West, a growing urban corridor at the mountain/plains boundary, and agricultural and rangelands that stretch to the Nebraska border in the east. As such, this region contains Colorado's most productive agricultural counties, the vast bulk of its population, and a large proportion of the people that recreate on public lands at the top of the basin. Consequently, human activity is a significant contributor to change in the South Platte environment. Population growth, land use, water use and quality, and climate change are and will continue to be major stressors on this system. FORT scientists have initiated a cooperative integrated assessment effort among state and federal agencies and universities to provide objective, spatially-explicit information on the state of the environment and natural resources of the South Platte Basin. The objective of the *South Platte Integrated Assessment* is to understand the complicated interactions between societal activities and public lands and resources, identify critical issues, and provide the science to inform future planning and management decisions.

STAFF

Science Director: **Zack Bowen**
Ph.D. Fishery Biologist: stream ecology, instream flow, impact analysis.

Allen, Craig, Ph.D. Research Ecologist: landscape ecology, forest ecology, biogeography, fire ecology, conservation biology, management applications of ecological information.

Andersen, Douglas, Ph.D. Ecologist: ecosystem, community, and population ecology; plant-animal interactions; terrestrial and riparian ecology.

Auble, Greg, Ph.D. Ecologist: riparian and wetland ecology, modeling, hydrology, operations research analysis, computer applications.

Baron, Jill, Ph.D. Research Ecologist: biogeochemical cycling/ecosystem ecology, water resources, watershed research, disturbance to alpine and subalpine ecosystems, regional integrated ecosystem analysis.

Friedman, Jonathan, Ph.D. Fluvial Geomorphologist: riparian and wetland ecology, dendrochronology, geomorphology, hydrology, plant community ecology.

Hogan, John, B.S. Physical Scientist: ecological field work, data collection and management, environmental education, and community-based science activities.

Kotliar, Natasha, Ph.D. Research Wildlife Biologist: avian ecology, fire ecology, wetland dynamics, landscape ecology, prairie dog ecosystems.

Roelle, James, Ph.D. Supervisory Wildlife Biologist: population dynamics, modeling, computer applications, riparian ecology.

Schoenecker, Kate, M.S. Wildlife Biologist: bighorn sheep and wild horse ecology and behavior, human effects of wildlife, conservation of unique and small wild horse populations, natural resource policy.

Scott, Mike, Ph.D. Ecologist: riparian and wetland ecology, dendrochronology, botany, forest ecology, fluvial geomorphology, plant community ecology.

Shafroth, Pat, Ph.D. Ecologist: riparian and wetland ecology, botany.

Singer, Francis, Ph.D. Research Biologist: conservation biology, large mammal population dynamics, mammalian predator dynamics, and ungulate herbivory, census techniques, and restoration.

Stottlemyer, Robert, Ph.D. Research Ecologist: ecosystem and watershed issues in parks, biogeochemistry, carbon and nutrient cycling.

Zeigenfuss, Linda, M.S. Ecologist: ungulate-plant interactions, ungulate habitat selection and population dynamics, ecological field work.

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Ecosystem Dynamics Program at
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INTERNATIONAL CENTER FOR APPLIED ECOLOGY

CAPABILITIES

Many natural resource issues are global and international in nature, including both causes and consequences. Migrating birds cross national boundaries, some declining and endangered species require habitat in more than one country, and biological species that are native to one country or continent can become costly invaders when they are established elsewhere. Solutions to international resource problems require cooperation among disciplines, coordination among agencies and universities, and agreements between nations. The International Center for Applied Ecology of the Fort Collins Science Center (FORT) is integrating science to address a variety of international natural resource problems, including neotropical migratory birds and bats in the Western Hemisphere; sustainable economic development and conservation in China; ecological risk management in Argentina; snow leopard and red-crowned crane conservation in Asia; several comparative ecology studies involving invasive plants in the U.S.; plague; and the endangered black-footed ferret and its Asian counterpart, the Siberian polecat. Biodiversity studies in central Asia use new technology such as satellite telemetry for tracking wildlife and DNA analysis for improving censusing methods.

Restoring and preserving natural systems globally depends increasingly on exchanging knowledge and expertise across nations. FORT brings scientists from other countries to the U.S. to build experience, share expertise, and generate a federal scientist network for use in this country and by countries of guest scientists. FORT scientists also offer technical assistance and training in cooperating countries.

SELECTED PROJECTS

Conserving Ecological and Cultural Diversity Through Sustainable Development. Many developing countries are seeking economic development strategies that will sustain their biological and cultural resources. For example, the Yunnan and Sichuan Provinces in Southwest China are among China's most biologically and culturally diverse. Twenty-six of China's 55 minority cultures have significant populations there, and poverty rates are high. Ecosystems range from tropical rain forests to 18,000-foot mountains. The U.S. Geological Survey (USGS)

is cooperating with provincial governments, universities, and the Chinese Academy of Sciences (CAS) to build economic development methods that will sustain biological and cultural diversity. Workshops held in the U.S. have trained Chinese scientists in connecting economic development, conservation biology, and GIS/GAP technologies. Currently, these integrated practices are being implemented in pilot projects in the Yunnan and Sichuan Provinces. In 2003, USGS and CAS will evaluate the pilot projects and extend activities to include invasive non-native species that move between China and the U.S. The techniques developed in Yunnan and Sichuan will be used in other western China provinces and applied elsewhere in the developing world.

Conservation Biology of Giant Tortoises in Galapagos. FORT research and management programs focused on the giant tortoises endemic to Galapagos involve studies of population biology, effects of introduced species, and *in situ* breeding and rearing of the most endangered populations. These efforts are followed by returning tortoises to native habitats that have been restored by parallel conservation programs involving control of introduced species, recovery of native plants communities, and management of human impacts. FORT scientists work closely with the Charles Darwin Foundation and Galapagos National Park on reptile biology and introduced species issues. Programs in the Galapagos National Park closely mirror major emphases of biological research capabilities of the USGS, including endangered species, introduced species management, GIS, and ecosystem management. All field aspects are conducted in Galapagos, Ecuador, but ancillary studies are conducted at FORT and in collaboration with cooperators at Yale University and the University of New Mexico.

Effects of Mining in Latin America. Developing countries in Latin America have vast potential mineral wealth that could be used to spur regional economies, but the rate at which these countries develop their resources could have serious consequences on natural resources and human health. To help prevent such impacts, FORT and the Servicio Geológico Minero Argentino produced a short course, *The Effects of Mining: Environmental, Human Health, and Ecological Risk Analysis,* for more than 70 scientists, engineers, planners, and medical personnel. The course covered the various facets of risk analysis as well as chemical, biological, and human health monitoring.

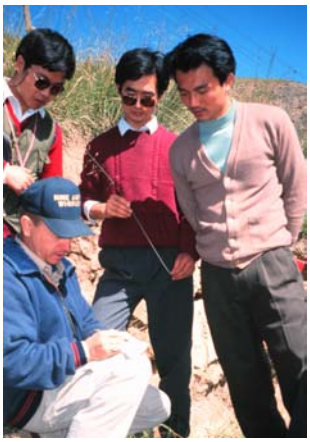
Migratory Birds in Latin America. The USGS and the Universidad Nacional de Salta are collaborating on a project sponsored by the National Geographic Society to study waterbirds of the southern altiplano. Nine Landsat ETM images (245,000 km^2) for six classes of aquatic bird habitats have been mapped and will be made available to the public on an interactive web site. Additionally, work with two universities and other cooperators in Argentina is investigating stable isotope analyses of feathers as a means of identifying wintering and breeding grounds of long-distance migrants and the migratory routes they follow.

Comparisons of Black-footed Ferret and Siberian Polecat. FORT scientists are collaborating with the Chinese Ministry of Forestry, the Northeast Forestry University in China, and the Institute of Biology in Russia on research to assist the restoration efforts of the endangered black-footed ferret in the U.S. FORT scientists are studying the ecology of the Siberian polecat, a member of its subgenus, as a surrogate for the black-footed ferret, whose restoration depends on captive propagation and survival after release into the wild. In order to identify potential problems with the release of captive-bred black-footed ferrets, this study uses radio-telemetry to compare movements, activity, and mortality of natural populations of Siberian polecats with populations that have been released from captivity. Genetic variation between the black-footed ferret and the Siberian polecat is being evaluated using molecular techniques. Comparative behavioral studies between captive black-footed ferrets and Siberian polecats are also being conducted. The research results are being applied to restoration plans guiding ferret recovery efforts in the U.S.

River and Stream Riparian Ecosystem Process Studies. Objectives of international activities associated with this project are twofold. First is to bring management expertise and scientific understanding of mechanisms gained in one country to bear on understanding related riparian ecosystems in other countries. Secondly, FORT scientists aim to work effectively on aspects of riparian ecosystem dynamics that are inherently international because they involve movement of species, water, or water-borne materials across national boundaries. Early steps have involved synthesizing information from international scientists and translating articles about riparian systems in arid and semi-arid landscapes, primarily Eurasia. In addition, international site visits have been conducted to become familiar with these related riparian systems and develop collaborative proposals. Of par-

ticular interest to FORT scientists is the autoecology of the plant genus *Tamarix* in its native range because of its extensive spread as an invasive species in riparian areas of the western U.S.

STAFF



Acting Science Director: **Don O. Hunter**
Ph.D. Ecologist: ecology, international conservation, information systems.

Boyle, Terence, Ph.D. Ecologist: biological and ecological indicators, ecotoxicology, ecological risk assessment.

Johnson, Richard L., M.S. Economist: ecological economics, international and development economics, resource economics and public policy, adaptive modeling and management.

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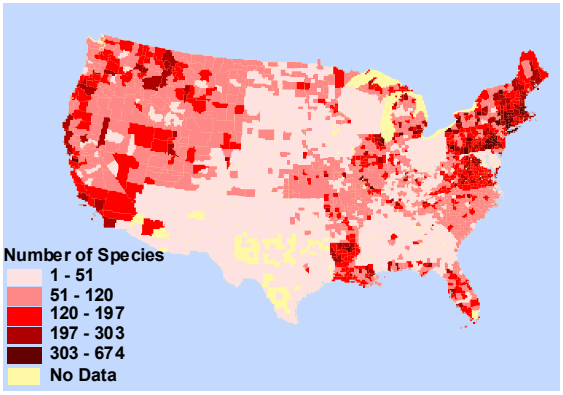
INVASIVE SPECIES SCIENCE

CAPABILITIES

Invasive, non-native species of plants, animals, and disease organisms adversely affect the ecosystems they enter. Like "biological wildfires," they can quickly spread and affect nearly all terrestrial and aquatic ecosystems. Invasive species have become the greatest environmental challenge of the 21st century in terms of economic, environmental, and human health costs, with an estimated impact in the U.S. of over $138 billion per year. Managers on Department of the Interior and other public lands, as well as the private sector, rank invasive species as their top resource management problem.



The Invasive Species Science Program of the Fort Collins Science Center (FORT) provides research and technical assistance relating to invasive species management concerns, including understanding how these species are introduced, identifying vulnerable areas, forecasting invasions, and developing control methods. To disseminate this information, FORT scientists are developing the Invasive Species Information Node of the National Biological Information Infrastructure (NBII), a comprehensive, accessible database of invasive species of plants, animals, and disease agents. From these data, and in partnership with Colorado State University, the National Aeronautic Space Administration (NASA), and others, FORT scientists are constructing models to understand and predict invasive species behavior for more effective management. FORT is also the administrative home of the *National Institute of Invasive Species Science*, a growing consortium of partnerships between government and non-government organizations established by the U.S. Geological Survey (USGS) and its many cooperators.

SELECTED PROJECTS

Wildfire, Fuel Treatments, and Non-Native Plant Species. Increasingly, public land managers are faced with having to protect natural places and processes along with residents of the wildland-urban interface, where these twin mandates can collide. In collaboration with the Western Forest Fire Research Center at Colorado State University, FORT scientists are conducting research to provide these managers with information that is applicable both ecologically and socially to pre- and post-fire management decisions. Avenues of investigation include the effectiveness of pre-wildfire fuel reduction treatments on reducing post-fire burn severity; the effects of wildfire on native and non-native plant species; and the interaction between seeded species and native plant species.

National Wildlife Refuge Invasive Species Inventory. The U.S. Fish and Wildlife Service (USFWS) manages over 500 national wildlife refuges, encompassing nearly 93 million acres and representing every major ecosystem type in the U.S. All are experiencing non-native plant invasions that threaten the refuges' ability to fulfill their conservation mission. A cooperative study between the USGS and the USFWS entails developing and implementing a system for gathering invasive species information from all refuges and coordinating that data for managers from local to national levels. With this synthesized information and the NBII Invasive Species database, managers will be able to prioritize control efforts for non-native species already present on their refuges. In addition, they will be able to track other non-native species in their vicinities, so they will know which species to watch for and attempt to eradicate before they become well-established.

Predictive Modeling for Invasive Plants. Invasive plant species pose a major threat to the integrity of native plant communities, often threatening rare and endangered plant species as well. Predicting invasive plant behavior in vulnerable areas is key to controlling them. FORT and NASA scientists have initiated a three-year cooperative agreement with colleagues at Colorado State University to substantially improve predictive modeling capabilities for invasive plant species. In February 2002, scientists began combining new rapid spatial analysis techniques with high-performance computing capabilities for broad applications in "ecological forecasting" of the invasion process. Funded by the Computational Technologies Program at NASA's Goddard Space Flight Center, the study's test data sets will focus on, and immediately benefit, Rocky Mountain National Park, Grand Staircase-Escalante National Monument, and areas burned in the Cerro Grande Fire in the Santa Fe National Forest, New Mexico.

Brown Treesnake. The brown treesnake is responsible for the extirpation of nearly all native bird species and most bats and lizards on Guam. It also exacts between $1 and 4 million per year in damages, including frequent power outages. Keeping this voracious snake from other non-infested islands, such as Hawaii and the Northern Marianas, is a top priority for the Department of the Interior's Office of Insular Affairs. In cooperation with other federal, state, and island agencies, FORT scientists working in Guam are making progress in toxicant research, trapping, population biology, venom research, and control strategies. In early 2002, they formed a rapid response team to address potential brown treesnake sightings in the Pacific. Based in Guam, this interagency team includes trained brown treesnake "searchers." When local authorities request the team's services, they quickly travel to the sighting location and use all available tools, in cooperation with local counterparts, to capture the snake or limit an infestation.

Establishing an Invasive Species Information Node of the NBII. Working with NASA, the NBII, the Natural Resource Ecology Laboratory at Colorado State University, the Biota of North America Program (BONAP), several USGS Science Centers, and many others, FORT scientists and cooperators

are developing a system for coordinating multiple types of data on both native and invasive non-native species across the U.S. This information will be accessible over the World Wide Web in conjunction with analysis tools that will allow the user to, among other applications, summarize data for an area, query surrounding areas to determine what non-natives are encroaching, and even model where current non-native species are likely to be located. Currently, a demonstration site is being developed using vegetation data from Colorado.

STAFF

Science Director **– Tom Stohlgren**

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Chong, Geneva, Ph.D. Ecologist: non-native and invasive species; landscape, plant, and fire ecology.

Crosier, Catherine, Ph.D. candidate. Ecologist: non-native and invasive species, spatial modeling, landscape ecology.

Dean-Bradley, Kathy, M.S. Zoologist: ecology and conservation of reptiles and amphibians.

Fritts, Thomas, Ph.D. Research Wildlife Biologist: evolution and ecology of reptiles and amphibians; arid, montane, and insular ecology.

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FORT COLLINS SCIENCE CENTER
POLICY ANALYSIS AND SCIENCE ASSISTANCE

CAPABILITIES

Most resource management decisions involve the integrated use of biological, sociological, and economic information. Combining this information provides a more comprehensive basis for making effective land management and conservation decisions. Toward this end, scientists in the Policy Analysis and Science Assistance Program (PASA) of the Fort Collins Science Center (FORT) contribute expert knowledge for natural resources management by conducting biological, social, economic, and institutional analyses of conservation policies and management practices.

PASA's mission is to integrate biological, social, and economic research so that resource managers can use the resulting information to make informed decisions and resolve resource management conflicts. PASA scientists pursue and conduct scientific analyses that help agencies and Native American tribes to (1) identify impending policy controversies and areas where earth and biological science research is needed to address future policy questions; (2) develop methods and approaches to assist researchers in preparing scientific evidence; (3) assess habitat alteration in a manner consistent with policy needs; and (4) evaluate policy options. Program scientists also evaluate policy options (e.g., effects of different land treatments, fish and wildlife management practices, or visitor/recreation management practices) in response to specific questions faced by policy-makers and managers.

MANAGEMENT, PLANNING, AND POLICY EVALUATION PROJECT

Visitor and Citizen Perceptions. This research is designed to elicit information about what the public perceives to be the important elements for sustaining communities and landscapes. Are there certain elements that residents of a community or visitors to a protected area think should be preserved, maintained, or restored to attain desired future conditions? The unique approach employed in this study in a national park and two regions of the Colorado Plateau has generated data that has helped managers assess public perceptions and preferences regarding various management scenarios.

Socioeconomic Impacts of Elk and Bison Management in the Southern Greater Yellowstone Area. Elk and bison herds inhabiting Grand Teton National Park and the National Elk Refuge represent one of the largest concentrations of free-ranging bison and elk in the world. Federal managers are devising a long-term strategy for managing these animals, which migrate across several jurisdictional boundaries. In so doing, they must balance many competing interests and address the economic impact of each proposed management alternative. In support of this process, PASA scientists are conducting research to quantify citizens' attitudes, knowledge, and preferences; determine economic values; and estimate the regional economic impacts, including local income and employment effects, related to these proposed management alternatives. Such information can yield valuable insights regarding the ramifications of each management option before it is proposed in an Environmental Impact Statement.

Natural Resource Negotiations. Since 1990, natural resource managers have seen a growing trend to include local stakeholders in the decision-making process. The Legal-Institutional Analysis Model (LIAM), developed by FORT social scientists as a tool for negotiation preparation, is designed to accomplish three goals: (1) plan for participation in a negotiation, (2) predict organizational behavior, and (3) examine likely negotiation strategies. LIAM has been used in collaborative decision-making efforts involving water, natural resource, and wildlife decisions throughout the United States and in Mexico. PASA scientists have also developed and continue to conduct courses in negotiations training in which participants learn and practice the principles, skills, and techniques used in successful natural resource negotiations. The courses are based on research that PASA scientists have conducted since the mid-1980's on multi-party natural research negotiations. For information about upcoming course offerings, see www.fort.usgs.gov/products, or contact the U.S. Fish and Wildlife Service's National Conservation Training Center.

DEVELOPMENT OF ADAPTIVE LAND MANAGEMENT MODELS AND PRACTICES PROJECT

Support to the U.S. Department of Agriculture's (USDA) Conservation Reserve Program. The USDA Conservation Reserve Program (CRP) is the largest conservation program in U.S. history, affecting land in all 50 states. Over 28 million acres of private land are planted to grasses under the CRP. Benefits to wildlife have been well documented and account in large part for widespread acceptance and several renewals of the program. PASA scientists have been conducting a long-term study looking at changes in CRP grassland composition and how these changes influence habitat quality for different species of wildlife. In addition, PASA scientists surveyed landowners on their perceptions about wildlife issues, the quality of assistance provided by USDA, and long-term management of CRP lands. This helps policymakers understand how the CRP program is working "on the ground" for participating farmers and ranchers. These cooperative studies between the USDA

and the U.S. Geological Survey focus on identification of economically and socially acceptable management practices that achieve long-term wildlife management goals associated with agricultural practices. The resulting information improves the effectiveness of the CRP.

Support to the Comprehensive Conservation Planning Process. The U.S. Fish and Wildlife Service is required by law to develop a Comprehensive Conservation Plan (CCP) for each unit of the National Wildlife Refuge System. A CCP guides management decisions and sets forth goals, objectives, and strategies for achieving refuge purposes. The CCP process offers a real opportunity to evaluate and improve habitat and wildlife management. In addition, each CCP must address the impacts of current and future social and economic conditions. FORT scientists are working with several refuges that are developing CCPs to (1) provide technical assistance in developing high-quality habitat objectives, and (2) provide and interpret data on the likely social, economic, and institutional results of each CCP management option. Over the past several years, FORT scientists have been developing and conducting workshops to help refuges develop habitat-based goals and objectives for their CCPs. Over the past 20 years, FORT scientists have provided other forms of technical assistance (on-site management consultations, simulation modeling, information synthesis, software development, and handbook publication) to over 200 refuges.

STAFF

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Caughlan, Lynne, Ph.D. Economist: natural resource policy, regional economic analysis.

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Ponds, Phadrea, M.S. Wildlife Biologist: human dimensions of wildlife and natural resource management.

Schroeder, Richard, B.S. Wildlife Biologist: habitat modeling, community modeling, habitat assessment, landscape ecology, ornithology.

Sexton, Natalie, M.S. Project Leader: human dimensions of wildlife management, natural resource management.

Stotler, Julie, B.S. candidate. Recreation and Tourism Specialist: on detail from Bureau of Land Management, 2002-2003.

Taylor, Jonathan, Ph.D. Social Science Analyst: natural resource negotiation, human perceptions of natural resources.

Contractor staff provide expertise in the areas of conflict resolution, instream flow policy, economics, and analysis of critical habitat designations.

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FORT COLLINS SCIENCE CENTER
SPECIES AND HABITATS OF FEDERAL INTEREST

CAPABILITIES

Ecosystem changes directly impact a wide variety of individual plant and animal species, native floral and faunal communities, and groups of species such as amphibians and grassland birds. Many species are dependent on suitable management of public lands for recovery from endangered status or to prevent listing under the Endangered Species Act. The Species and Habitats of Federal Interest Program of the Fort Collins Science Center (FORT) conducts research on the ecology, habitat requirements, distribution and abundance, and genetics and systematics of many such species. FORT scientists also develop reintroduction and restoration techniques, as well as technologies for monitoring populations and analyzing data. FORT expertise lies in both traditional and specialized natural resource disciplines, including wildlife biology, population dynamics, animal behavior, plant and community ecology, inventory and monitoring, statistics and computer applications, conservation genetics, stable isotope analysis, and museum curation.

SELECTED PROJECTS

Ecology of Prairie Dogs and Black-footed Ferrets. Early research in the black-footed ferret recovery program focused on the ecology of a remnant free-ranging population of ferrets in Wyoming, emergency rescue of ferrets for captive breeding, refining methods of captive propagation, and developing the process of reintroducing ferrets back into their native prairie dog habitats. More recently, FORT scientists and collaborators have developed methods to evaluate and compare habitat for reintroductions, assisted in developing a canine distemper vaccine for captive and wild ferrets, and pioneered a new strategy for rearing ferrets that has resulted in a 10-fold increase in post-release survival. Current research emphasizes the ecology and management of plague, a disease that threatens prairie dogs and ferrets. Scientists have found improved methods for controlling fleas on prairie dogs, which should reduce the probability of plague outbreaks. Studies recently initiated on translocations of the threatened Utah prairie dog have resulted in a 50-fold increase in short-term retention of prairie dogs at release sites.

Declining Amphibians in Colorado and Wyoming. Amphibian populations are declining worldwide. Locally, declines in populations of boreal toads in Rocky Mountain National Park have caused concern among park managers. FORT scientists are investigating the habitat use and population dynamics of resident boreal toads as well as measures of amphibian health and possible disease influences. Nationally, FORT represents the Southern Rocky Mountains in the Department of the Interior's (DOI) Amphibian Research and Monitoring Initiative (ARMI), the largest program focused on amphibian decline to be funded by Congress. ARMI concentrates efforts on long-term monitoring and specific research questions relating to amphibian declines. FORT scientists work with DOI agencies to design and implement monitoring programs to ensure that data collected can be used effectively in management decisions and provide input into the broader scale, national scope of ARMI.

Ecology of Virus Transmission in Commensal Bat Colonies. In 2001, FORT scientists joined with Colorado State University and the Centers for Disease Control and Prevention to conduct a bat study in the city of Fort Collins. This study aims to better understand the population dynamics of bats in urban-suburban areas, how bats interact with people and human structures, and how they transmit viruses to one another. The study focuses on the big brown bat, a species that commonly roosts in homes, buildings, cracks in trees, and other sites throughout the U.S.

Stable Isotopes: Providing Answers to Ecological Questions. Stable isotopes of various chemical elements occur naturally in all ecological systems. The power of stable isotopes in ecological studies hinges on two important traits. First, when an animal ingests water and food, its body tissues take on chemical "signatures" of the geographic area where it resides. Second, the chemical signature of natural environments varies across the surface of the earth. Taking advantage of these traits, FORT scientists are investigating the possibility that isotopic analyses of an animal's tissues (e.g., fur, feathers) may indicate the location of its breeding and non-breeding habitat, tell a more complete story about its migration patterns, or help to establish its feeding ecology and links to other components of the ecosystem.

Prairie Birds: Declining Populations and Disappearing Habitats. FORT scientists are developing and applying innovative approaches and the latest research technologies to studies of the demography, migratory movements, foraging ecology, behavior, and conservation of avian species in the mountain-prairie region of the U.S. These approaches include stable isotope analysis, genetic tools, radio-telemetry, and geographic information systems (GIS). For example, FORT scientists are studying population dynamics and causes of decline in two endemic avian species of the short-grass prairie ecosystem, the Mountain Plover and Lark Bunting. In a study on migratory movements and ecology of shorebirds that traverse the continental interior, FORT staff are helping to develop a hemispheric shorebird monitoring program, developing models for habitat restoration and conservation planning, and evaluating the effects of weather cycles and global climate change on habitat availability and landscape connectivity.

Rocky Mountain Center for Conservation Genetics and Systematics. The Rocky Mountain Center for Conservation Genetics and Systematics was initiated as the result of a collaborative effort between FORT and the University of Denver. Genetic techniques can be used to augment studies of population dynamics and population viability, refine taxonomic definitions, investigate gene flow, and document genetic diversity. Ongoing studies at the Center include population genetics studies of rare and declining species such as the Greater Sage Grouse, Gunnison Sage Grouse, Trumpeter Swan, Mountain Plover, Lesser Prairie Chicken, Midget Faded Rattlesnake, and the rare plant taxon, *Potentilla rupincola*.

Curation of the Biological Survey Collection. FORT scientists manage and curate a valuable collection of vertebrates that belongs to USGS and its predecessor agencies. Located in the Museum of Southwestern Biology on the University of New Mexico campus, the collection is particularly rich in specimens of bats and rodents from western Federal lands and includes a unique collection of fishes from the Upper Colorado River Basin. The collection supports ongoing research that focuses on the status and distribution of listed species and species of special management concern in the Southwest. All specimen records are fully computerized and the mammal records are searchable online. Future plans include georeferencing all specimen records.

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Skagen, Susan K., Ph.D. Research Wildlife Biologist: migration ecology, declining grassland birds, shorebirds, avian ecology.

Stanley, Thomas, Ph.D. Research Wildlife Biologist: quantitative population biology, avian and mammalian ecology, statistical modeling.

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