U.S. Department of the Interior
Geological Survey

Northern Rocky Mountain Science Center

2010 Annual Report

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Welcome! What follows is the annual report of the science and research at the Northern Rocky Mountain Science Center (NOROCK) for 2010. We've had a productive year at the Center as well as moving into a brand new building in Bozeman that will increase our science capabilities. Our science partnerships and collaborations continue to grow and we look forward to working with you. We hope you'll find the information useful and if you would like to have reprints or copies of the publications mentioned, or would like more information on our projects, please feel free to contact us or visit our website at: http://www.nrmsc.usgs.gov/.

Jeff Kershner, Center Director

About the Center

The Northern Rocky Mountain Science Center (NOROCK) is part of the Rocky Mountain Area of the USGS. Scientists from the Center work in the northern Rocky Mountains of the United States and throughout the western U.S. Many of our scientists work throughout the world on issues as diverse as global climate change, aquatic ecology, wildlife diseases, bison ecology, and large carnivores. Researchers work with partners from the Department of the Interior including the Bureau of Land Management, Bureau of Reclamation, National Park Service, and the U.S. Fish and Wildlife Service. Researchers also work in collaboration with state resource agencies throughout the United States and other federal agencies such as the U.S. Forest Service. We are co-located at Montana State University.

Mission

The mission of the Northern Rocky Mountain Science Center is to produce and disseminate scientific information needed to manage and restore the ecosystems and associated plant and animal communities of the Northern Rockies.

Vision

The Center will generate and communicate unbiased, scientifically sound information needed to address issues of critical importance to natural resource managers of the region. The Center will be recognized for its ability to anticipate and address key issues effectively through research and information transfer, and for its collaborative approach to problem solving. Whenever feasible, the Center will continue to pursue integrated, interdisciplinary science within the USGS, with universities, other agencies, and non-governmental organizations.

Current Staffing

Our science staff includes ecologists, zoologists, wildlife biologists, aquatic biologists, statisticians, plant ecologists, and geographers, plus a science support staff of biologists, physical scientists, biology and hydrology technicians, and administration.

- 31 Federal Staff
- 4 Center Management
- 12 Research scientists
- 9 Science Support
- 3 Admin Support
- 3 SCEP graduate students

- 60 Non-Permanent Staff
- 27 STEP
- 12 TERM Appointments
- 21 Other Temp

To see our complete Center Staff, visit: http://nrmsc.usgs.gov/staff

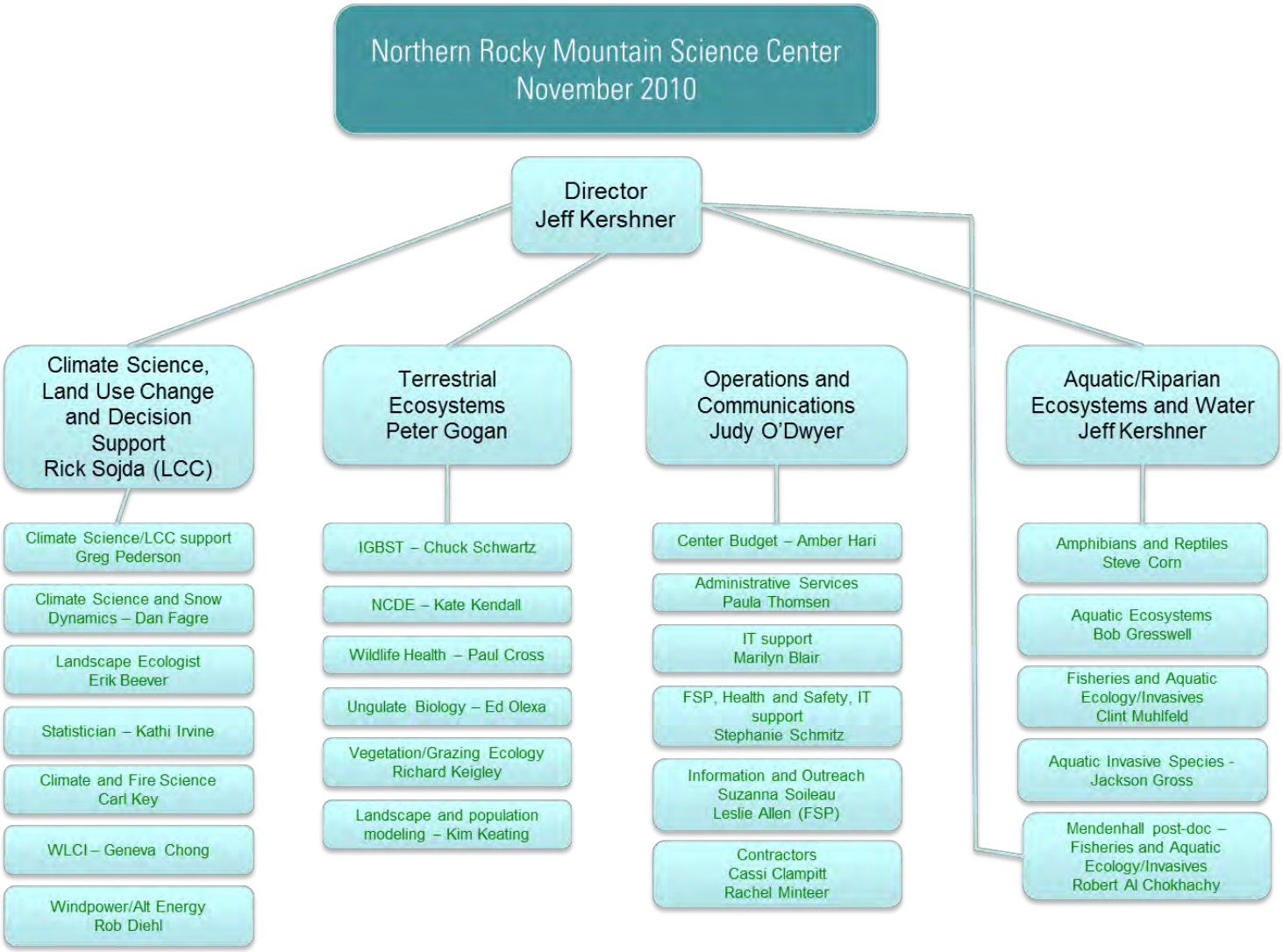
History

The Northern Rocky Mountain Science Center is one of 18 biological science and information technology centers within the USGS. The Center was formed in January 2000 by the U.S. Geological Survey to conduct integrated, interdisciplinary research in support of natural resource management in the Northern Rocky Mountains. Researchers are based at Bozeman, Montana with field stations at West Glacier and Missoula, Montana and a duty station in Jackson, Wyoming. Researchers work in collaboration with Federal, state, and International agencies, Native American tribes, academic institutions, and organizations to produce and disseminate scientific information needed to support natural resource management decisions.

NOROCK scientists and partners at the 2010 Open House in Bozeman, Montana.

Partners

Major partners include Montana State University, USGS Montana Water Center, USGS Montana Cooperative Fisheries Research Unit, the National Park Service, the U.S. Fish and Wildlife Service, the Bureau of Land Management, Bureau of Reclamation, the U.S. Forest Service, NASA, NOAA, the University of Montana, Montana Department of Fish, Wildlife and Parks, Wyoming Game and Fish Department, and Idaho Department of Fish and Game. Researchers also collaborate with numerous partners through the Interagency Grizzly Bear Committee, Greater Yellowstone Coordinating Committee, Great Northern Landscape Conservation Cooperative, Plains and Prairie Pothole Landscape Conservation Cooperative, Greater Yellowstone Interagency Brucellosis Committee, Rocky Mountain Cooperative Ecosystem Studies Unit, Northern Yellowstone Cooperative Wildlife Working Group, Trout Unlimited, Pacific Flyway Council, Montana Wetland Council, Big Sky Institute, Intermountain Joint Venture, and other joint ventures. Our role in all of these activities is to provide objective scientific information that can be used by others in making natural resource



*Direct reports are shown in this figure. Other staff exist in a number of programs including full time scientists, technicians, post-docs and graduate students.

New Staff

In late 2010, NOROCK brought in 3 new permanent staff, 2 new term appointments, and a Mendenhall Post Doc. These researchers have increased the Center's science capabilities and strengthened our partnership capacity.

⇒ USGS Research Ecologist Erik Beever
⇒ USGS Statistician Kathi Irvine
⇒ USGS Radar Ornithologist Rob Diehl
⇒ USGS Biologist Andy Ray
⇒ USGS Biologist Adam Sepulveda
⇒ USGS Fisheries Biologist and Mendenhall Postdoctoral Fellow Robert Al-Chokachy

NOROCK Research Emphases

In 2007, the USGS developed a new science strategy outlining major natural-science issues facing the Nation and focusing on areas where natural science can make a substantial contribution to the well-being of the Nation and the world. These areas include global climate change, water resources, natural hazards, energy and minerals, ecosystems, and data integration. Science accomplishments of the Northern Rocky Mountain Science Center are based on government goals specific to protection and conservation of natural resources and fall under these new programming areas. Our Center function and biological science focuses around four main themes: Climate Science, Land Use Change and Decision Support; Terrestrial Ecosystems; Aquatic/Riparian Ecosystems and Water; and Operations and Communications.

Climate Science, Land Use Change and Decision Support:

The increasing pressure of private land development adjacent to public lands, expanding energy production, and continued commodity extraction on world class wildlife resources requires more complicated analyses to identify potential consequences and trade-offs of management alternatives. Couple that with global climate change, and resource managers face unprecedented challenges in the management of natural resources. We work collaboratively with managers in the northern Rockies and elsewhere to evaluate these changes and predict their impacts on terrestrial and aquatic ecosystems. We work closely with the Great Northern Landscape Conservation Cooperative and the Plains and Prairie Pothole Landscape Conservation Cooperative to cooperatively identify needed research and to help translate this research in ways that are useful to managers. We are developing models and decision support tools that use this information to display the effects of management alternatives on the resource goals identified by managers and the public.

Terrestrial Ecosystems:

The Northern Rockies are blessed with an abundance of plant and animal species that have remained relatively intact since the Lewis and Clark expedition in the early 19th century. Energy development, increasing human population pressures, and the continued demand for more water make the management of wildlife more complicated than ever. We work with partners to study key life history and habitat needs of these species. Our scientists develop work on a variety of research topics including wildlife habitat and population modeling, wildlife disease, ungulate browsing effects on vegetation, and plant community and habitat interactions.

Aquatic/Riparian Ecosystems and Water:

Native fish and amphibian populations have declined drastically throughout North America over the past century as a consequence of habitat degradation and nonnative species introductions. Although management actions have improved the probability of persistence of the these taxa in some areas, recent invasions of nonnative species (e.g., lake trout, rainbow trout, New Zealand mud snails, bull frogs, and Asian carp) present challenges to the persistence of native species. We work closely with managers to understand the most pressing management issues and to develop research that supports their efforts.

Operations and Communications:

To ensure the efficiency and efficacy of our science, our Operations staff works directly with Center researchers to help meet the functionality and staffing needs of each program. In addition, the Science Information and Education Team ensures that Center science is highlighted and accessible in various media formats and “stands-out” to both regional and national audiences.

Climate Science, Land Use Change, and Decision Support

Developing models and decision support tools to display the effects of management alternatives on the resource goals identified by managers and the public.

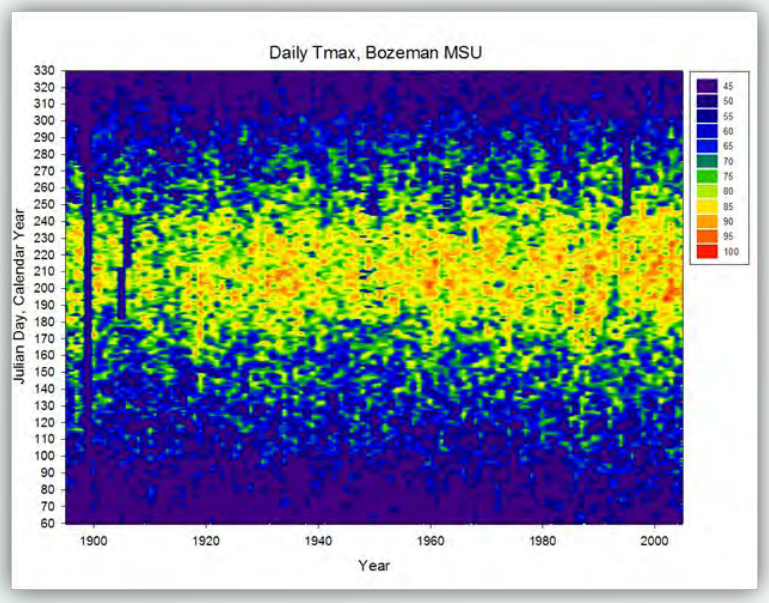
Paleoclimate and Climate Impacts on Natural Resources

Lead: USGS Ecologist Greg Pederson
http://nrmsc.usgs.gov/staff/gpederson/research

This research is focused primarily on climate variability and its role in driving biological and physical components of mountainous ecosystems of western North America. In addressing these issues, instrumental and tree-ring based records of climate is used to assess the time intervals and spatial scales over which these processes operate. Of particular interest is the influence of interdecadal climate regimes, long-term temperature trends, and ocean-atmosphere connections in driving observed changes in mountain snowpack, streamflow, glaciers, and forest disturbance events. Recent studies have addressed the susceptibility of natural resources within national parks and protected areas to climate variability and change, and sought to apply both the modern and paleoclimatic records to present day resource management problems.

Featured Science: Climate Analysis Tools

Over 100 years of daily and monthly temperature data collected in western Montana was analyzed for long-term changes in seasonal averages and daily extremes. The objectives of this work were to: (1) describe rates of change in temperature averages and extremes for western Montana, a region containing sensitive resources and ecosystems, (2) investigate associations between Montana temperature change to hemispheric and global temperature change, (3) provide climate analysis tools for land and resource managers responsible for researching and maintaining renewable resources, habitat, and threatened/endangered species and (4) integrate our findings into a more general assessment of climate impacts on ecosystem processes and services over the past century. The daily temperature time series reveal extremely cold days (≤-17.8°C) terminate on average 20 days earlier and decline in number, whereas extremely hot days (≥32°C) show a three-fold increase in number and a 24-day increase in seasonal window during which they occur. Results show that regionally important thresholds have been exceeded, the most recent of which include the timing and number of the 0°C freeze/thaw temperatures during spring and fall. Finally, we close with a discussion on the implications for Montana's ecosystems. Special attention is given to critical processes that respond non-linearly as temperatures exceed critical thresholds, and have positive feedbacks that amplify the changes.



Pederson, G.T., L.J. Graumlich, D.B. Fagre, T. Kipfer and C.C. Muhlfeld. 2009. What do recent temperature trends portend? A view from western Montana, USA. Climatic Change 96: DOI 10.1007/s10584-009-9642-y, 22pp.

Climate Change in Mountain Ecosystems Program

Lead: USGS Research Ecologist Dan Fagre
Staff: Lisa Mckeon, Lindsey Bengtson, Erich Peitzsch, Blase Reardon
http://nrmsc.usgs.gov/research/global.htm

Climate change is widely acknowledged to be having a profound effect on the biosphere with many and diverse impacts on global resources. Mountain ecosystems in the western U.S. and the Northern Rockies in particular are highly sensitive to climate change. In fact, the higher elevations of the Northern Rockies have experienced three times the global average temperature increase over the past century. These same ecosystems provide up to 85% of the water humans depend on as well as a host of other ecosystem services such as snow-based recreation, timber, unique flora and fauna, and critical habitat for rare and endangered species such as bull trout and grizzly bear. Climate change poses special problems for mountain protected areas, such as national parks and wilderness areas, because most of the land area within their boundaries is at higher elevations. What will be the effects of continued climate change on mountain resources and our national parks? How should managers monitor and react to climate change? To answer these questions, we have been monitoring, conducting research, and modeling ecosystem responses to climatic variability since 1991, first at Glacier National Park but eventually throughout the western U.S. in collaboration with other scientists. Coordination with scientists around the world have led to mountain research networks to expand our understanding of how mountain ecosystems respond to climate change

Featured Science: Retreat of Glaciers in Glacier National Park

In Glacier National Park (GNP), MT some effects of global climate change are strikingly clear. Glacier recession is underway, and many glaciers have already disappeared. The retreat of these small alpine glaciers reflects changes in recent climate as glaciers respond to altered temperature and precipitation. It has been estimated that there were approximately 150 glaciers present in 1850, and most glaciers were still present in 1910 when the park was established. In 2010, we consider there to be only 25 glaciers larger than 25 acres remaining in GNP. A computer-based climate model predicts that some of the park's largest glaciers will vanish by 2030. This is only one model prediction but, if true, the park's glaciers could disappear in the next several decades. However, glacier disappearance may occur even earlier, as many of the glaciers are retreating faster than their predicted rates.

http://nrmsc.usgs.gov/files/norock/products/GlacierRecession_infosheet2010_SRC_040910.pdf

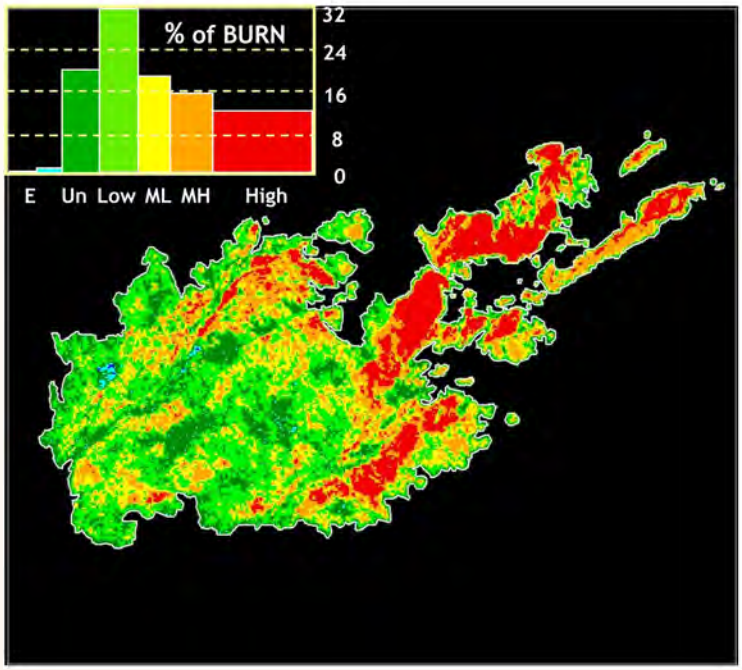
Fire Science

Lead: USGS Geographer Carl Key
http://nrmsc.usgs.gov/science/fire/burn_severity

The ecological significance of wildfire is now recognized globally, and needs to monitor and predict variations due to fire are widely accepted. Goals to sustain natural systems and biodiversity, enhance habitat, and mitigate unnatural fuel buildups are tempered by potential impacts from global biomass burning, and risks to human life and property where developments encroach on large natural areas. In addition, the potential influence of climate change in wildfire are not well known. Our scientists are building capabilities for the remote sensing and evaluation of burns to understanding how climate may control burn patterns and heterogeneity, and influence subsequent responses in western U.S. forest ecosystems. Working with diverse institutions and individuals in fire science and information technology, we are advancing mutual interests of fire science partners by undertaking relevant research and by disseminating findings through coordination and technology transfer.

Featured Science: Climate Impacts on Burn Severity

This project assesses fire trends from 1984 to 2008, and the role that climate has played in wildfire burn severity in three forest biomes of the United States. We are investigating how climate variability, trends and connections contribute to landscape-scale heterogeneity from wildfire over the past 25 years. Study areas include regions surrounding Yukon Charlie Rivers National Preserve, Yosemite National Park and Glacier National Park. Partners include the three National Park areas, plus the University of Washington, the University of Idaho. This project intends to serve as a pilot to 1) address the roles of climate in wildfire burn severity, 2) develop new summary metrics of burned area, and 3) demonstrate the utility of burn severity atlases in assessing landscape scale changes related to complex hierarchical controls. Results will be broadly relevant to global change science and fire science, including regional- and national-level resource management and research. Results also should provide useful guidance for local scientists and managers within the three study areas. Our research strategy and approach should offer valuable models for scientists using similar data or exploring similar questions in other regions.



Example of burn data extracted by perimeter including burn severity levels or classes.

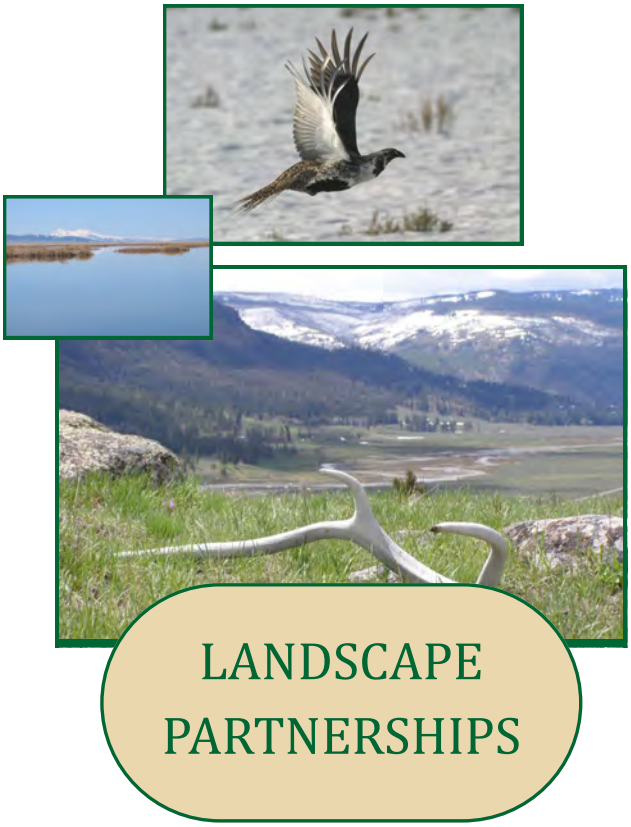
Terrestrial Invasive Species

Lead: USGS Research Ecologist Geneva Chong
http://nrmsc.usgs.gov/staff/gchong/research

Ecosystem change results from multiple, interacting factors, and many of those factors may be human-influenced such as climate, grazing, fire, flood, and land-use. Non-native species are one factor in ecosystem change that interacts with all other factors and provides a model system for not only monitoring ecosystem change but also for forecasting components of ecosystem change such as changes in species composition and structure, which, in turn, alter habitat and disturbance processes. We are actively cultivating relationships with management agencies to promote the use of comparable vegetation monitoring methods to facilitate ecosystem-level analyses of ecosystem change.

Featured Science: Vegetation Sampling in Yellowstone National Park

Along with our partners, we established multiple types of vegetation sampling methods concurrently and on top of historic vegetation sampling methods and locations. We mapped the occurrence of cheatgrass and three non-native species of interest to Yellowstone National Park. Results will provide tools to Park managers to assist in selecting the best sampling methods for northern range vegetation and where to establish additional sampling points to determine drivers of vegetation change. Study findings should be helpful regarding vegetation sampling and data analyses, including modeling, to estimate vegetation distributions under future climate scenarios.



Wyoming Landscape Conservation Initiative

The WLCI is a long-term science based effort to enhance aquatic and terrestrial habitats at a landscape scale in Southwest Wyoming, while facilitating responsible development." (http://www.wlci.gov/). The WLCI study area encompasses the southwest corner of Wyoming where extensive energy development is impacting wildlife, vegetation, air, land, water and human social structures including agriculture. NOROCK scientist Geneva Chong and her WLCI partners established near-surface reflectance, incoming solar radiation, air temperature and soil moisture sampling platforms in conjunction with remotely-sensed information (greenness) and ground-truth vegetation plots (multi-scale and photo). These data were used to determine reasons for anomalous green-up on the Jonah Oil Field, WY and effectiveness of cheatgrass control. Multi-scale vegetation plots were established on historic sagebrush reduction treatments to determine long-term impacts on vegetation structure and composition with particular interest in Greater Sage-grouse habitat. In addition study findings should be helpful regarding native species management and control, such as using automated sensing of early green-up to assist managers in the decision to end feeding of elk on state feedgrounds, which may reduce the transmission of disease.

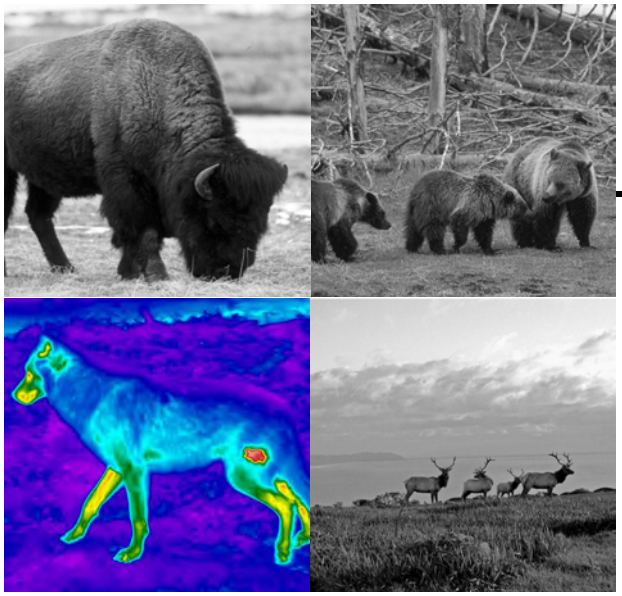
Great Northern Landscape Conservation Cooperative

The Great Northern Landscape Conservation Cooperative (GNLCC) is a partnership-directed conservation alliance focused on providing collaboration and coordination for strategic landscape conservation (http://nrmsc.usgs.gov/gnlcc). The GNLCC was jointly convened by U.S. Fish and Wildlife Service and the National Park Service in the spring of 2010. Federal, State, Tribal, Provincial and non-government organizations have been invited to participate. The GNLCC is working towards landscape conservation across the middle to northern Rocky Mountains and interior Columbia Basin. The GNLCC is connected with a number of landscape-level conservation partnerships within the Great Northern area to identify conservation priorities and related science and information needs within three eco-geographic areas: Rocky Mountain, Columbia and Sage - Steppe. The Northern Rocky Mountain Science Center has contributed significant resources to this effort including the role of GNLCC Science Coordinator, held by USGS Wildlife Biologist Rick Sojda. In addition new USGS staff were recruited in 2010 to assist the GNLCC in their science needs. These staff include USGS Research Ecologist Erik Beever and USGS Statistician Kathi Irvine. Our Science Information Specialists also work on the GNLCC communication and outreach efforts.

Science Team about Energy and Prairie Pothole Environments

In the United States, the Williston Basin occupies 143,000 square miles and includes portions of Montana, North Dakota, and South Dakota. Superimposed over this landscape is the Prairie Pothole Region (PPR) which includes critical wetland and grassland habitats of importance to breeding, nesting, and migrating waterfowl, and wetland and grassland birds. A potential impact of oil field activities on these important habitats is brine contamination from co-produced waters that leach from oil well reserve pits, injection wells, and transport lines. Previous studies have identified contamination of wetlands and groundwater resources, including drinking water aquifers, located on U.S. Fish and Wildlife Service (USFWS), tribal, and public lands, and numerous groups have expressed concern over the potential risk of contamination. Currently, the extent of such contamination across the Williston Basin is unknown, and there is a need for scientific-based information to assess this threat.

The USGS has placed a focused effort on providing a comprehensive understanding of the Nation's energy and mineral resources and the environmental effects of their use. In response to this, a collaborative initiative known as Science Team about Energy and Prairie Pothole Environments (STEPPE) has been developed between USGS scientists from the NOROCK, Northern Prairie Wildlife Research Center, Montana Water Science Center, and the Crustal Imaging and Characterization Team (http://steppe.cr.usgs.gov/). STEPPE is working to identify areas within the Prairie Pothole and Williston Basin region of Montana, North Dakota, and South Dakota that are most at risk to contamination from energy development. The group is also assessing the extent of past and current oil well development in the region and the potential impacts on aquatic resources.



Terrestrial Ecosystems

Developing work on a variety of research topics including wildlife habitat and population modeling, wildlife disease, ungulate browsing effects on vegetation, and plant community and habitat interactions.

Wildlife Health

Lead: USGS Disease Ecologist Paul Cross
Staff: Mike Ebinger, Montana State University
http://nrmsc.usgs.gov/staff/pcross/research

Much of the interest in disease ecology and wildlife health has been prompted by the emergence, or resurgence, of parasites that move between livestock, wildlife, and/or humans. Almost 75% of all emerging human infectious diseases are zoonotic and many livestock disease issues are associated with repeated introductions from wildlife species. However, parasites are also passed in the other direction from domestic hosts to wildlife hosts and these parasites may affect the long-term conservation of wildlife species. Unprecedented human population abundance and distribution combined with anthropogenic environmental change has resulted in dramatic increases in human-animal contact, thus increasing the intimate linkages between animal and human health. Our scientists collaborate with a number of partners including Wyoming Game and Fish Department, Montana State University, University of Montana, Penn State University, Yellowstone National Park and Montana Fish Wildlife and Parks. Together, we are working on some of the most pressing wildlife health issues around the Greater Yellowstone Ecosystem.

Featured Science: Probable Causes of Increasing Elk Brucellosis in Northwestern Wyoming

Data suggested that free-ranging elk are a maintenance host for *Brucella abortus* in new areas of the Greater Yellowstone Ecosystem (GYE). Brucellosis seroprevalence in free-ranging elk increased from 0–7% in 1991–1992 to 8– 20% in 2006–2007 in four of six herd units around the GYE. These levels of brucellosis are comparable to some herd units where elk are artificially aggregated on supplemental feeding grounds. Data suggest that enhanced elk-to-elk transmission in free-ranging populations may be occurring due to larger winter elk aggregations. Elk populations inside and outside of the GYE that traditionally did not maintain brucellosis may now be at risk due to recent population increases. In particular, some neighboring populations of Montana elk were 5–9 times larger in 2007 than in the 1970s, with some aggregations comparable to the Wyoming feeding-ground populations. In a subsequent study we looked at a 19-year dataset of over 6400 brucellosis tests of adult female elk. Data show that management captures that occurred from January to March were over two times more likely to be seropositive than hunted elk that were killed in September to December, while accounting for site and year effects. Areas with supplemental feeding grounds for elk had higher seroprevalence in 1991 than other regions, but by 2009 many areas distant from the feeding grounds were of comparable seroprevalence.

Cross, P. C., E. K. Cole, A. P. Dobson, W. H. Edwards, K. L. Hamlin, G. Luikart, A. D. Middleton, B. M. Scurlock, and P. J. White. 2010. Probable causes of increasing elk brucellosis in the Greater Yellowstone Ecosystem. Ecological Applications 20(1): 278-288.

Interagency Grizzly Bear Study Team

Lead: USGS Research Wildlife Biologist Chuck Schwartz
Staff: Mark Haroldson, Shannon Podruzny, Karrie West, Chad Dickinson
http://nrmsc.usgs.gov/research/igbst-home.htm

The Interagency Grizzly Bear Study Team (IGBST) is an interdisciplinary group of scientists and biologists responsible for long-term monitoring and research efforts on grizzly bears in the Greater Yellowstone Ecosystem (GYE). The team is composed of representatives from the U.S. Geological Survey, National Park Service, U.S. Fish and Wildlife Service, U.S. Forest Service, Wind River Fish and Game, and the States of Idaho, Montana, and Wyoming. This interagency approach ensures consistency in data collection and allows for combining limited resources to address information needs throughout the GYE. We annually monitor the grizzly bear population and habitat in the GYE. Examples include:

- Distinguishing unique females with cubs of the year.
- Radio-collaring a representative sample of bears to estimate rates of reproduction and survival, movement patterns, habitat use, and denning chronology.
- Documenting distribution of females with young throughout the ecosystem.
- Documenting where, when, and how many bears die (mortalities) annually in the GYE.
- Monitoring annual trends in key foods including winter-killed bison and elk, spawning cutthroat trout, whitebark pine cone production, and bear use of cutworm moth aggregation sites.

Featured Science: Hazards Affecting Grizzly Bear Survival in the GYE

We modeled annual survival of grizzly bears in the GYE to 1) identify landscape features (i.e., foods, land management policies, or human disturbances factors) that best describe spatial heterogeneity among bear mortalities, 2) spatially depict the differences in grizzly bear survival across the GYE, and 3) demonstrate how our spatially explicit model of survival can be linked with demographic parameters to identify source and sink habitats. Data spanned from 1983–2003 and contained 11,888 telemetry records during 6,992 months from 362 bears. Encounter histories contained 1,004 records (bear–yr), with 75 recorded mortalities. The most important predictors of survival in the best model were amount of secure habitat within a bear's home range and road densities outside of secure habitat. The number of homes per section and roads associated with these developments were the best predictors of grizzly bear survival on private lands. Model results can be used by managers to help identify and prioritize areas in the ecosystem where additional management is necessary to ensure long term persistence grizzly bears.

Schwartz, C. C., M. A. Haroldson, G.C. White. 2010. Hazards Affecting Grizzly Bear Survival in the Greater Yellowstone Ecosystem. Journal of Wildlife Management 74(4):654-667.

Northern Divide Grizzly Bear Project

Lead: USGS Research Biologist Katherine Kendall
Staff: Amy Macleod (University of Montana)
http://nrmsc.usgs.gov/research/NGSbear_monitoring.htm

The Northern Divide Grizzly Bear Project monitors grizzly bear populations in the Northern Continental Divide Ecosystem (NCDE) in northwest Montana—one of the last strongholds of the grizzly bear in the lower 48 states. Of the six established grizzly bear recovery zones, the NCDE is the third largest in area, potentially harboring the greatest number of grizzly bears, and is the only zone contiguous to a strong Canadian population. However, little information exists about the bears in this region and as agencies strive to recover the threatened grizzly bear, it is clear that there is a need to assess the grizzly bear population in the NCDE. Managers and biologists are working to identify population size, trend, survival, and the corridors that link separate populations. Advances in genetic technology allow us to address these parameters through the identification of species, sex, and individuals from DNA extracted from bear hair without ever handling a bear.

Featured Science: Monitoring Bear Populations with Non Invasive Sampling

The goal of this research project is to evaluate the effectiveness of noninvasive sampling to monitor trends in the threatened grizzly bear population in the NCDE of northwestern Montana. This work uses hair collection methods similar to those used in the 2004 to estimate population abundance in the NCDE as part of the Northern Divide Grizzly Bear Project. However, instead of generating a snapshot of population size, this new work will collect bear hair over multiple years to determine how the population changes over time. We will use detections of individual bears at un-baited, naturally-occurring bear rubs (trees, posts, and poles that bears rub on) to examine population trends, including changes in abundance, survival rate, regional density, and genetic structure. Hair collected from bear rubs can detect a large portion of the population. For example, over half of all male grizzlies and a quarter of all females in the population were detected on bear rubs in 2004. By sampling rubs throughout the NCDE and sampling in late summer and fall, we expect to detect even more of the population each year. Collecting hair from bear rubs may be a safe, reliable, and cost-effective way to sample bear populations and monitor their status over time.

Stetz, J. B., K. C. Kendall, and C. Servheen. 2010. Evaluation of bear rub tree surveys to monitor grizzly bear population trends. Journal of Wildlife Management. 74(4):860-870.

Ungulate Biology

Lead: USGS Wildlife Biologist Ed Olexa
http://nrmsc.usgs.gov/staff/eolexa/research

Our research is assessing the impact of land management activities on the spatial and temporal distribution of ungulate populations and identifying the impact of ungulate herbivory on Department of Interior managed areas. Current research involves identifying spatial and temporal aspects of elk distribution to be used in resource protection on protected areas administered by the National Park Service and assessing elk response to land management activities on BLM grazing allotments.

Featured Science: Ecology of Elk on the Landscape in Southwest Wyoming

Long-term research began in 2005 to address concerns of the National Park Service and Wyoming Game and Fish Department regarding potential resource degradation resulting from a growing elk herd and associated increased grazing use of Fossil Butte National Monument. Over 70 elk have been radio-collared on Fossil Butte National Monument and neighboring Bureau of Land Management lands near Cokeville, Wyoming, since 2005. Collars remained on each animal for three years and thus far have produced nearly 210,000 locations documenting elk use. Understanding the timing of elk movements is as equally important as knowing where they move, and this is especially true for Fossil Butte National Monument. High elk use may have a significant impact on vegetation. While cattle grazing on the Monument was discontinued in 1989, land managers remain concerned about the impact of high densities of overwintering elk. Our study found that the timing of elk movement appears linked to the hunting season. Data show that elk move onto the Monument in the fall when archery hunting begins and move off of the Monument in the spring (Figure 1).

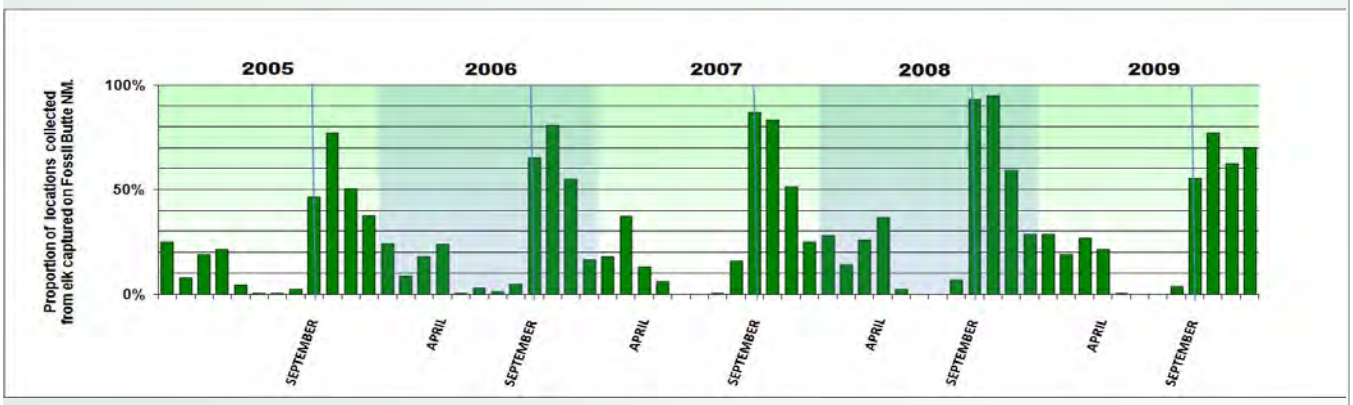


Figure 1. Timing of elk movement onto and off of the Fossil Butte National Monument.

http://nrmsc.usgs.gov/files/norock/products/Olexa_090210_FINAL_red.pdf

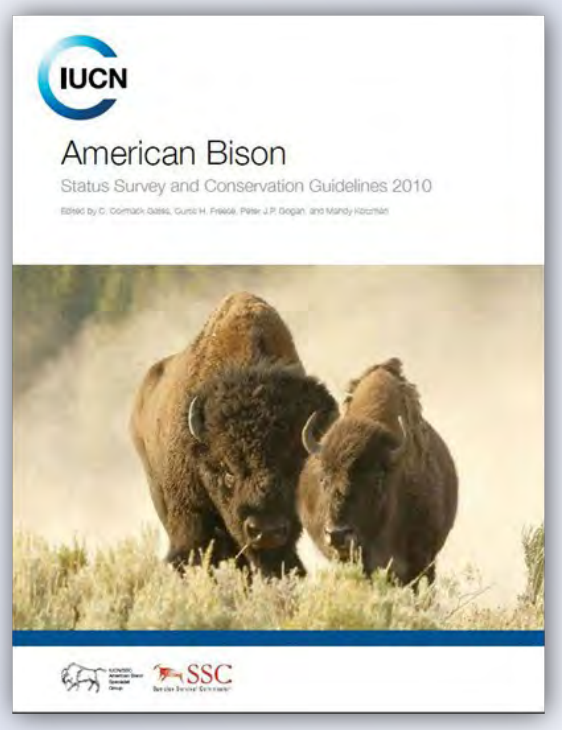
North American Bison Research

Lead: USGS Research Wildlife Biologist Pete Gogan
http://nrmsc.usgs.gov/staff/pgogan/research

North American bison (*Bison bison*) once roamed the plains of North America from northern Mexico to Alaska in numbers of tens of millions. Today, there are about 430,000 bison roaming throughout the US, with the vast majority in private ownership and around 20,000 in conservation herds managed by federal and state agencies. Though they are not in danger of extinction, there are indications that the present populations are threaten by both genetic hybridization with domestic cattle – a result of efforts to breed a more robust "beefalo" breed in the early 1900s – and exposure to livestock diseases.

Featured Science: The Status of North American Bison

To investigate the diverse topics that need to be considered by researchers, managers, policy makers and others interested in restoring and conserving this magnificent animal, the International Union for Conservation of Nature (IUCN) American Bison Specialist Group, which includes Center scientist Pete Gogan, brought together the expertise of over thirty scientists to share their knowledge and ideas in a comprehensive review of the American bison status – American Bison: Status Survey and Conservation Guidelines 2010. The publication of this IUCN American Bison Status Survey and Conservation Guidelines is timely owing to a recent convergence of factors: new research findings on bison genetics and ecology, assessment and awareness of the precarious status of many bison conservation herds, new initiatives by government and non-profit institutions to improve management of existing herds and to establish conservation herds, growing interest among Native Americans in restoring bison as part of their cultural heritage, and an increasing awareness by the commercial bison industry that conservation of wild-type bison is in the longterm interest of the industry. There is also a growing body of evidence that the biodiversity of ecosystems within the original range of bison can benefit from bison restoration, from the desert grasslands of northern Mexico, through the Great Plains, to the lowland meadow systems of interior Alaska.



Current research at NOROCK is examining the Yellowstone National Park bison herd in order to better understand the biology of this key bison population and aid in the development of long term conservation plans. Along with our partners, we are investigating the potential for limited gene flow across this population using multilocus Bayesian clustering analysis.

Gogan, P. J. P., N. C. Larter, J. H. Shaw and J. E. Gross. 2010. General biology, ecology and demographics. Pages 39 – 54 in Gates, C. C., C. H. Freese, P. J. P. Gogan and M. Kotzman. 2010 (editors). American bison status survey and conservation guidelines 2010. International Union for the Conservation of Nature, Gland Switzerland. 134pp.

Vegetation and Grazing Ecology

Lead: USGS Research Ecologist Richard Keigley
http://nrmsc.usgs.gov/staff/rkeigley/research

The level of browsing by wild and domestic ungulates is an important influence on the structural diversity and species composition of plant communities. Under low browsing pressure, young plants attain their potential stature and contribute to the structural diversity of the community by replacing older plants as they die. The resulting vegetation structure and species composition produces habitat that is of value to a variety of wildlife, including breeding birds. If browsing pressure increases to a level that prevents young plants from growing through the browse zone, structural diversity will decrease and species composition will be altered. The resulting habitat becomes less suitable for the original suite of wildlife, including the wild ungulates that contributed to the altered state. To effectively manage for sustainable habitat requires the ability to detect declines in structural diversity at an early stage.

Featured Science: Development of Browse Evaluation Programs

We established browse evaluation programs at six National Wildlife Refuges in Colorado. At Alamosa NWR preliminary data found that willow habitat for the endangered southwestern willow flycatcher is in decline, tentatively attributed to a combination of flow control of the Rio Grande River and browsing by elk. In cooperation with the Colorado Divisions of Wildlife (CDOW), the elk herd was reduced at Alamosa and future elk management will be based on the methods introduced in 2009. At the Baca NWR, researchers found that browsing by elk is causing the decline of willow habitat. In cooperation with CDOW, an ungulate management program is under development and future monitoring will be based on methods introduced in 2009. The 2009 findings will be incorporated into the Baca Comprehensive Conservation Plan that will begin development in 2011.

In Prairie County, Montana a Landscape Level Survey of the Cherry Creek Big Game Trend Area determined that there has been an increase in ungulate browsing over the past several decades, and that virtually all woody plant species were in decline. If the current trend continues, woody draw habitat will be eliminated. We are in the process of distinguishing livestock from wildlife use and are exploring the potential role of seeding large areas to crested wheatgrass during the 1930s; such seeding would have removed the native prairie vegetation as a food source and forced the increasing deer population to concentrate on woody draw vegetation for nutrition. The potential interaction of the loss of native prairie in the 1930s and the planting of crested wheatgrass has implications for developing management strategies to preserve the woody draw habitat.

Landscape and Population Modeling

Lead: USGS Research Wildlife Biologist Kim Keating
http://nrmsc.usgs.gov/staff/kkeating/research

Ecosystems increasingly show signs of stress from multiple causes. Global climate change, land development, invasive species, and altered fire regimes are but a few of the factors that threaten large-scale ecological change. Our research is aimed at understanding the species-habitat relationships central to ecosystem structure and function, and at developing the mathematical methods and models needed to predict consequences of impending changes over broad landscapes. Field studies address wildlife-habitat relationships for ungulates and large carnivores—species that commonly exhibit long-distance movements, and which require relatively intact ecosystems with large areas of suitable habitat to sustain healthy populations. This fieldwork is complemented by research to develop improved statistical methods for modeling wildlife-habitat relationships over large ecosystems. Such models provide an important decision-support tool for resource managers seeking to identify key habitats or predict impacts of management alternatives.

Featured Science: Modeling Wildlife-Habitat Relationships

This ongoing program of basic research is aimed at developing enhanced quantitative methods for modeling habitat use and selection. In 2010, a grant from the USGS Wildlife Program was used to purchase a "personal supercomputer". With 1360 computing cores, this machine represents a major advance over the previously available workstation and is enabling development of new, more robust statistical approaches to building niche and habitat selection models. Work in 2010 focused on refinement of the mathematical underpinnings of these models and on developing the expertise in Fortran GPU-accelerator programming that is pre-requisite to capitalizing on this cutting edge technology.
It is anticipated that this work will lead to new modeling methods that (1) automatically address nonlinear responses, (2) are broadly applicable across species and scales, (3) simultaneously yield both niche and selection models, (4) automatically account for interactions among covariates, and (5) allow for direct use of any covariate type (including linear, circular, and categorical terms), thereby enabling direct and continuous modeling of temporally dynamic patterns.

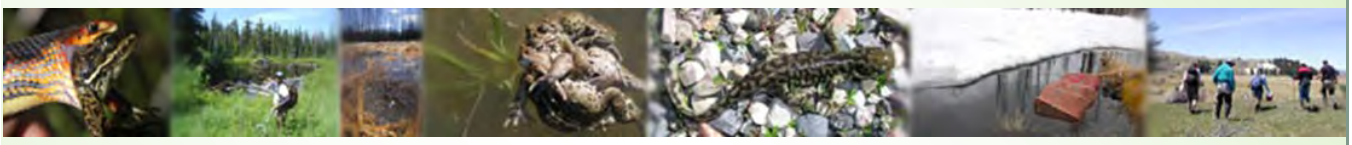
Aquatic Ecosystems and Water

We work closely with managers to understand the most pressing management issues and to develop research that supports their efforts. In aquatic ecosystem conservation.

Amphibians and Reptiles

Lead: USGS Research Zoologist Steve Corn
Staff: Blake Hossack
http://nrmsc.usgs.gov/rarmi

The Department of the Interior's Amphibian Research and Monitoring Initiative (ARMI) is designed to determine where populations of amphibians are present, to monitor specific populations and to investigate potential causes of decline and deformity. The Rocky Mountain Region of ARMI encompasses Montana, Wyoming, Colorado, and New Mexico. Two USGS Science Centers initiate and develop ARMI projects in this region—NOROCK and Fort Collins Science Center (FORT), Colorado. Information from surveys in the Rocky Mountains is used to determine the occupancy of species of amphibian in a target area. These data are compiled at the national level where the information will be used in designing new surveys and framing hypotheses to be tested about amphibian presence, amphibian decline, and other related issues such as deformity and disease.



Featured Science: Long –Term Monitoring of Amphibian Populations

One key aspect of ARMI is intensive monitoring at a few key sites, known as Apex Sites. The emphasis at these sites is on population processes and how these are influenced by factors that may be important contributors to global amphibian declines. Our scientists conduct studies at several Apex Sites in Montana, Wyoming, and Colorado that produced important results in 2010. All of these studies demonstrate that long-term data are necessary to fully examine the complex issues involved in global amphibian declines.

⇒ Year-to-year survival of adult toads, modeled from capture-recapture data, is influenced by whether toads are infected with *Batrachochytrium dendrobatidis* (Bd), thought to be a major cause of global declines. Toads that tested positive for the presence of Bd had lower survival rates than toads that were free of Bd.

⇒ The population dynamics of Columbia spotted frogs in the Bitterroot Mountains in Montana has been studied since 2000 by graduate students at the University of Montana, who have demonstrated that survival of different life stages is higher after winters with less snow accumulation.

⇒ A long term study on boreal chorus frogs in northern Colorado has produced insights into the relationships between climate and breeding phenology and documented how this relationship affects the potential exposure of frog embryos to ultraviolet radiation. Currently, population estimates from these populations are being compared to recordings made by automated systems to determine whether recordings can provide an index to abundance.

⇒ Effects of wildfire on amphibians have just begun to be explored in forests with stand-replacement fire regimes. Research in Glacier NP affords a unique opportunity to measure how populations respond to wildfire. Further research expands into neighboring managed forests to determine whether there are additive or interactive effects of wildfire and forests management.

Hossack, Blake R., Muths, Erin, Anderson, Chauncey W., Kirshtein, Julie A., and Corn, Paul Stephen. 2009. Distribution limits of *Batrachochytrium dendrobatidis*: a case study in the Rocky Mountains, USA. Journal of Wildlife Diseases 45:1198–1202.

Landscape-Scale Impacts on Native Trout and Salmon

Lead: USGS Research Biologist Bob Gresswell
http://nrmsc.usgs.gov/staff/bgresswell

Fishery biologists and managers are increasingly consumed with the recovery and restoration of native trout and salmon throughout the western United States. These fish historically inhabited a variety of freshwater habitats, but have declined due to habitat degradation, fragmentation, and introductions of nonnative species. Complicating these issues is global warming and associated climate change, which are likely to increase air and water temperatures, increase the risk of catastrophic fire, change the timing and quantity of water from snowpack, increase winter flooding in some areas, and provide habitat conditions that favor introduced species.

Featured Science: Landscape-Scale Impacts on Native Trout and Salmon

We are working with the next generation of scientists to examine how large-scale landscape changes may impact native fisheries. Examples of graduate research in fishery science include:

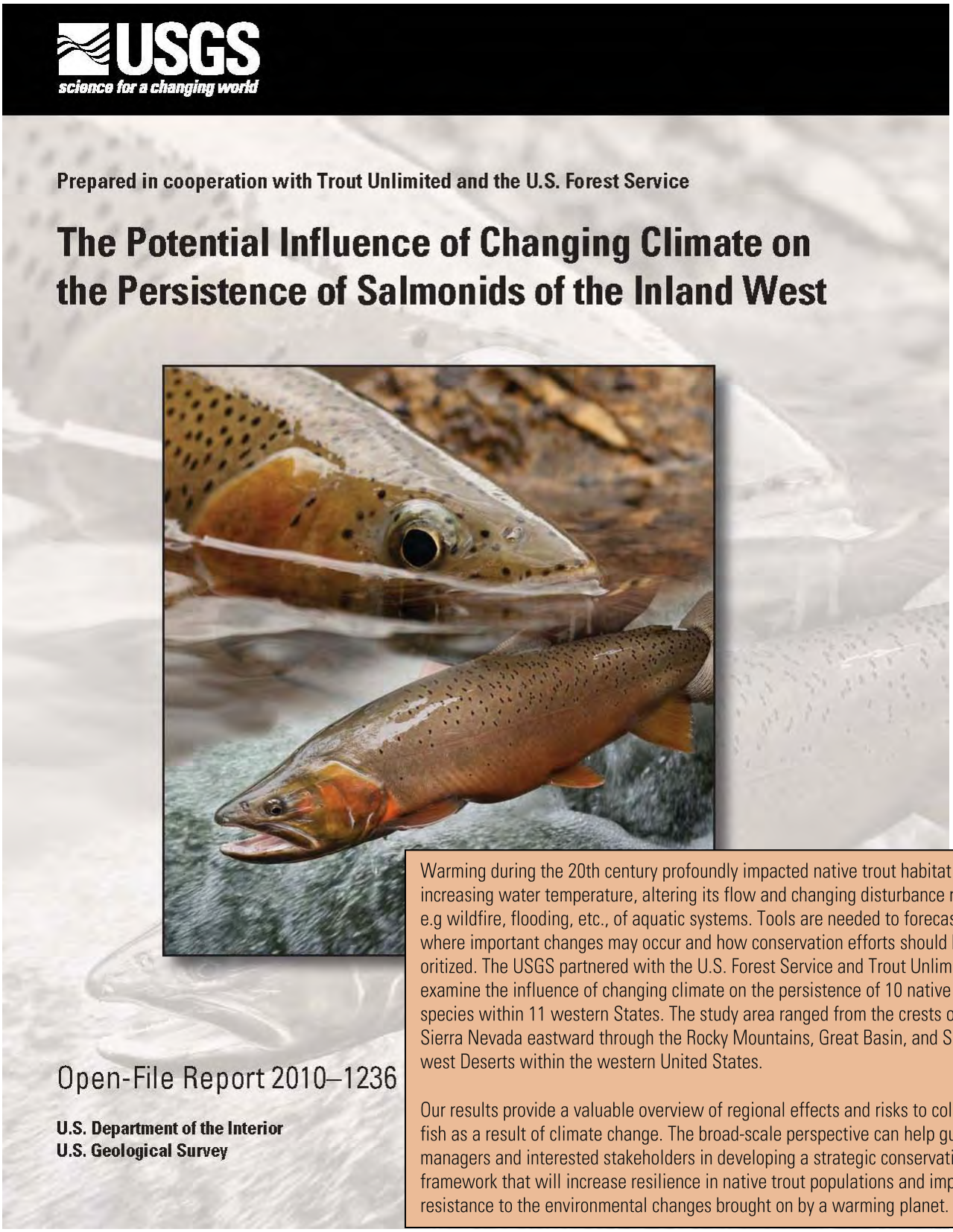
⇒ **Silver Bow Creek, Montana:** We are examining the recolonization of Silver Bow Creek by tributary populations of westslope cutthroat trout and other native fishes currently occupying the watershed, post a century of mining. The study will monitor fish movements within the tributaries and from the tributaries into Silver Bow Creek with the goal of identifying critical habitats of cutthroat trout, migration barriers, and other potential impediments to fish recovery in Silver Bow Creek.

⇒ **Snake River, Wyoming:** We are using radio telemetry to determine distribution of Snake River finespotted cutthroat trout spawning populations and the physical characteristics of the Snake River that influence the relative abundance of spawners. According to preliminary analyses, individuals spawning in the same locations tend to occupy the same portions of the river before and after spawning. Research suggests that these fish exhibit complex behavioral strategies that connect spawning habitat in the watershed with movements across a range of spatiotemporal scales.

⇒ **Big Hole River, Montana:** To better understand how habitat conditions affect the distribution of fish, we are using passive integrated transponder (PIT) technology to monitor fish movement and assess the effects of coldwater refugia on the distribution of fishes. Data will be used to evaluate the potential interaction of invasive fishes and climate change on the persistence of threatened Arctic grayling, with the ultimate goal of providing information for planning and evaluating conservation projects in the watershed.

⇒ **Colorado River, Colorado:** We are conducting coarse and fine-scale spatial analyses of debris flow potential and the spatial distribution and abundance of cutthroat trout in twelve high elevation headwater streams of the Colorado Rocky Mountains. Ultimately, results can be used to direct planning strategies to minimize effects from catastrophic fires in those areas and identify fish populations at risk of extirpation.

http://nrmsc.usgs.gov/files/norock/products/Gresswell_2010_1.pdf



Warming during the 20th century profoundly impacted native trout habitat by increasing water temperature, altering its flow and changing disturbance regimes, e.g wildfire, flooding, etc., of aquatic systems. Tools are needed to forecast where important changes may occur and how conservation efforts should be prioritized. The USGS partnered with the U.S. Forest Service and Trout Unlimited to examine the influence of changing climate on the persistence of 10 native trout species within 11 western States. The study area ranged from the crests of the Sierra Nevada eastward through the Rocky Mountains, Great Basin, and Southwest Deserts within the western United States.

Our results provide a valuable overview of regional effects and risks to coldwater fish as a result of climate change. The broad-scale perspective can help guide managers and interested stakeholders in developing a strategic conservation framework that will increase resilience in native trout populations and improve resistance to the environmental changes brought on by a warming planet.

Haak, A.L., Williams, J.E., Isaak, D., Todd, A., Muhlfeld, C., Kershner, J.L., Gresswell, R., Hostetler, S., and Neville, H.M., 2010, The potential influence of changing climate on the persistence of salmonids of the inland west: U.S. Geological Survey Open-File Report 2010–1236, 74 p.

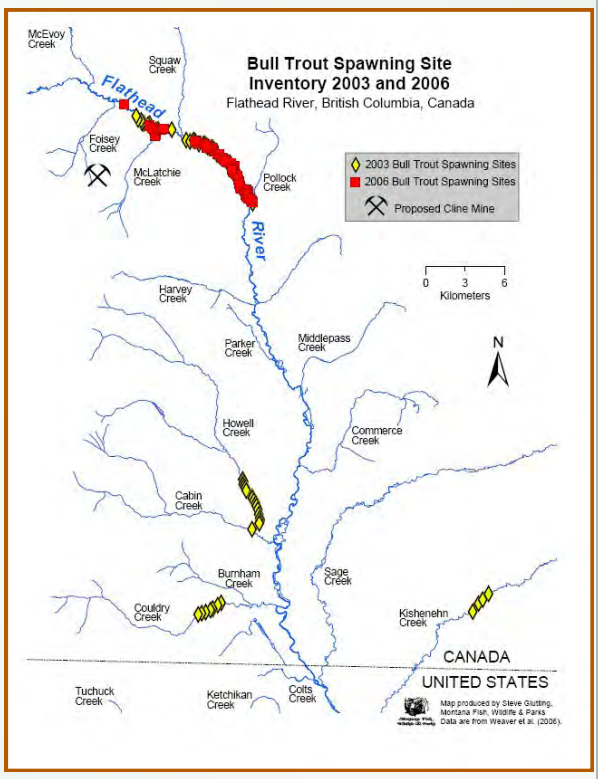
Fisheries and Aquatic Ecology

Lead: USGS Research Ecologist Clint Muhlfeld
Staff: Vin D'Angelo, Joe Giersch, Carter Fredenberg, Leslie Jones, Brady Miller
http://nrmsc.usgs.gov/staff/muhlfeld/research

Part of our Aquatic Ecosystem Program is located at Glacier National Park, Montana. This program focuses on various aspects of aquatic ecology, fisheries biology, and conservation of native aquatic biota. Research spans a range of research questions and conservation issues. We are examining the impacts of hybridization and competition between native and non-native salmonids, assessing life history diversity and genetic structure of native fishes, investigating the impacts of hydroelectric dams on aquatic ecosystems, and developing quantitative bioenergetics and population viability models for fish populations and aquatic communities.

Featured Science: Implications of Mining in the Transboundary Flathead

The Transboundary Flathead Basin in Montana (U.S.) and British Columbia (Canada) hosts one of the most diverse and unique native aquatic ecosystems throughout North America. Headwaters of the basin feed into Waterton-Glacier International Peace Park (U.S. and Canada) and Flathead Lake in the U.S. Despite the tremendous historical and ecological value of the region, the Canadian headwaters are targeted for coalbed methane drilling and open-pit coal mining. This can threaten water and habitat quality, migratory fish populations, and all aquatic life downstream. In 2008 we led an international aquatics research project to help the U.S. prepare to meet this challenge and protect the ecosystems of the Transboundary Flathead Basin Ecosystem. In September 2009, a joint United Nations Educational, Scientific and Cultural Organization and the International Union for Conservation of Nature (UNESCO/IUCN) team visited the Flathead in Montana and British Columbia to investigate whether the proposed mining was a threat to Waterton-Glacier International Peace Park. During this trip, our scientists and partners presented current research findings to the team. In January 2010 a draft report was released which included the team's analysis of the potential impacts of mining in the Flathead. Currently mining in the region is not being implemented. Whatever the long term outcome of potential mining in the region, science from USGS and our partners provided the data to inform conservation and management decisions impacting this diverse and sensitive transboundary system.



The spawning and movement of bull trout in the Transboundary Flathead Basin.

http://nrmsc.usgs.gov/files/norock/products/FishMining_Info10.pdf

Aquatic Invasive Species

Lead: USGS Biologist Jackson Gross
http://nrmsc.usgs.gov/staff/jgross/research

Aquatic Invasive Species (AIS), also known as aquatic nuisance species, are non-native invasive species that negatively impact aquatic ecosystems and human services. AIS have impacted nearly every aquatic ecosystem in the United States, posing risks to native species within those ecosystems, as well as human and wildlife health. Our research on aquatic invasives is exploring new and innovative mechanisms of aquatic invasive species control and eradication for the conservation of aquatic ecosystems. These studies will help provide managers with appropriate data to conduct suppression and eradication efforts on aquatic invasive and nuisance species.

Featured Science: New Aquatic Invasive Program Kicks Off at NOROCK

In 2010 several technologies were examined not only within the Northern Rocky Mountains, but across the country—expanding the range of application to invasives threatening other ecosystems across the nation:

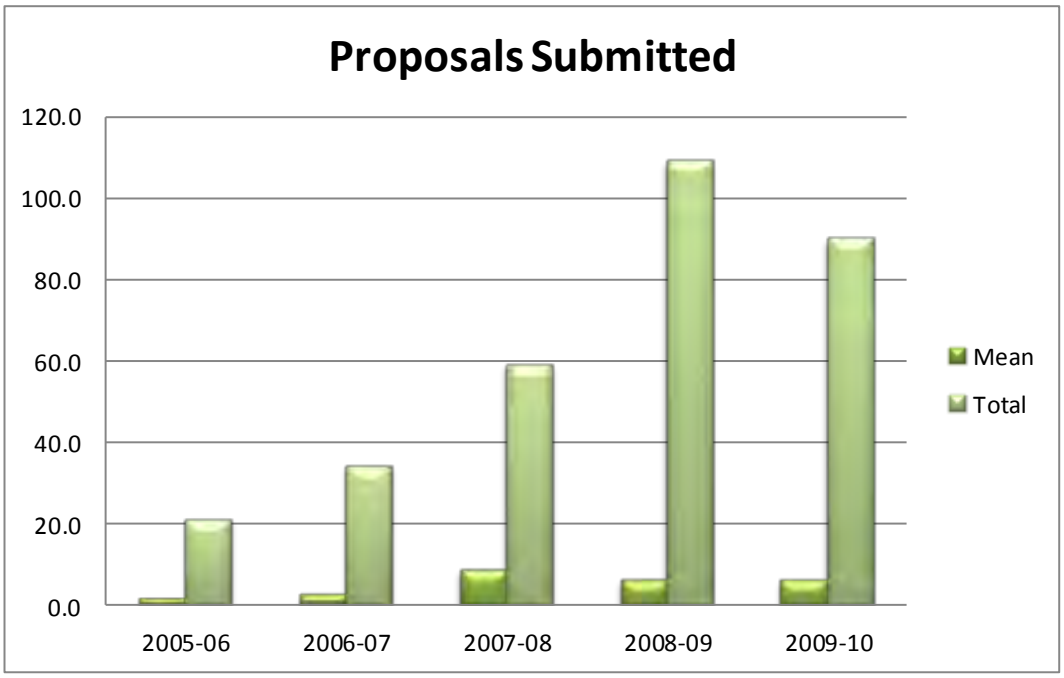
- ⇒ Assessed the ability of water jet and suction technology on Lake trout embryos in spawning grounds in Yellowstone Lake. (Yellowstone National Park)
- ⇒ Completed a one year study on nutrient modification to assess the role of diet to inhibit lake trout recruitment. (Wyoming, Minnesota)
- ⇒ Conducted experiments to inhibit the spread of Asian clam larvae from Gavin's Point National Fish Hatchery. (South Dakota)
- ⇒ Conducted studies using sound pressure technologies to prevent the spread of Asian carp into the Great Lakes Ecosystem. (Illinois)
- ⇒ Evaluated the effects of suction and water jet technology to inhibit the spread of New Zealand mud snails and restore Bonneville cutthroat trout spawning habitat on the Bear River. (Idaho)
- ⇒ Initiated studies to control and eradicate Northern Pike from important salmon spawning and rearing habitat from South Central Alaska. (Alaska)
- ⇒ Conducted the studies on the effects of electricity on salmonid embryos and developed electro-shocking technologies for the eradication of salmonid embryos on spawning grounds. (Montana)
- ⇒ Conducted research on effects of dissolved carbon dioxide on salmonid embryos and larvae. (Montana)

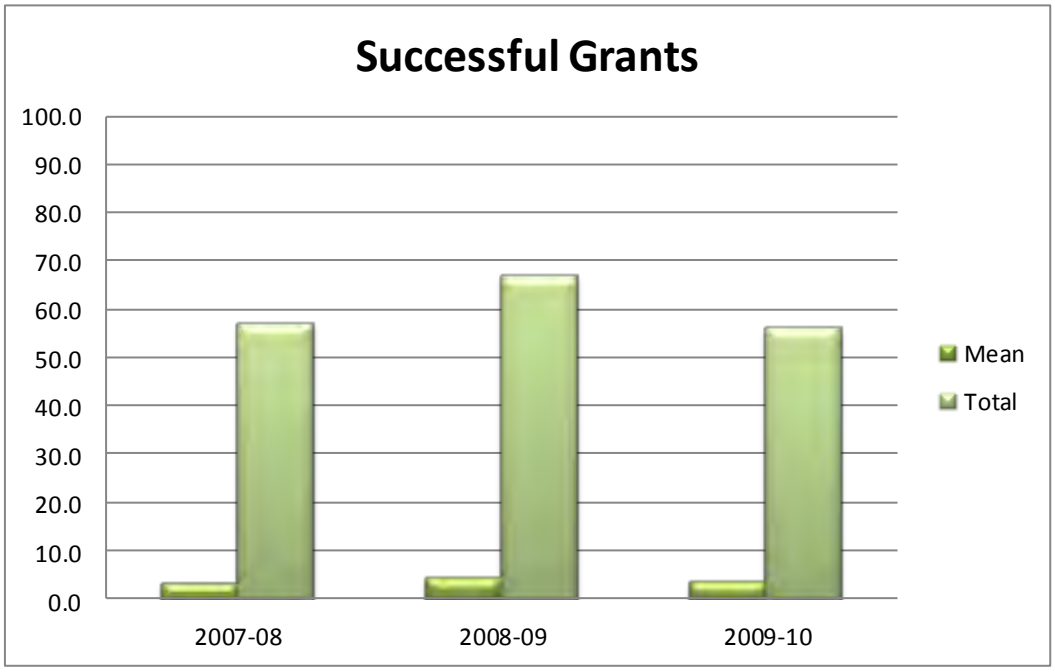
Center Productivity

Center science is highlighted and accessible in various media formats and "stands-out" to both regional and national audiences.

New Projects in 2010-2011

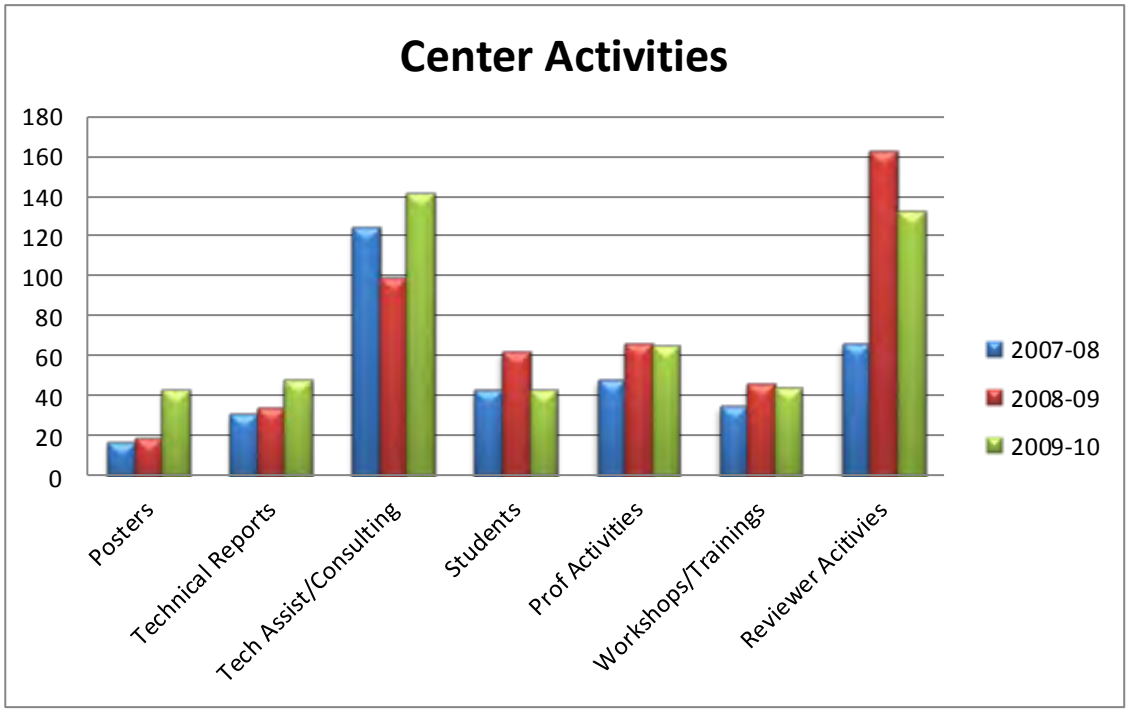
In 2010 our researchers were awarded approximately $6.8 million in grant funding to support ongoing and emerging research in and around the Northern Rocky Mountains.





NOROCK Activities

Our research yields multi faceted opportunities to present our findings, as well as provide consultation and technical service to our partners. In addition we mentor and advise future scientists pursuing undergraduate and graduate degrees in natural resource science. The chart below illustrates activity in 2010.

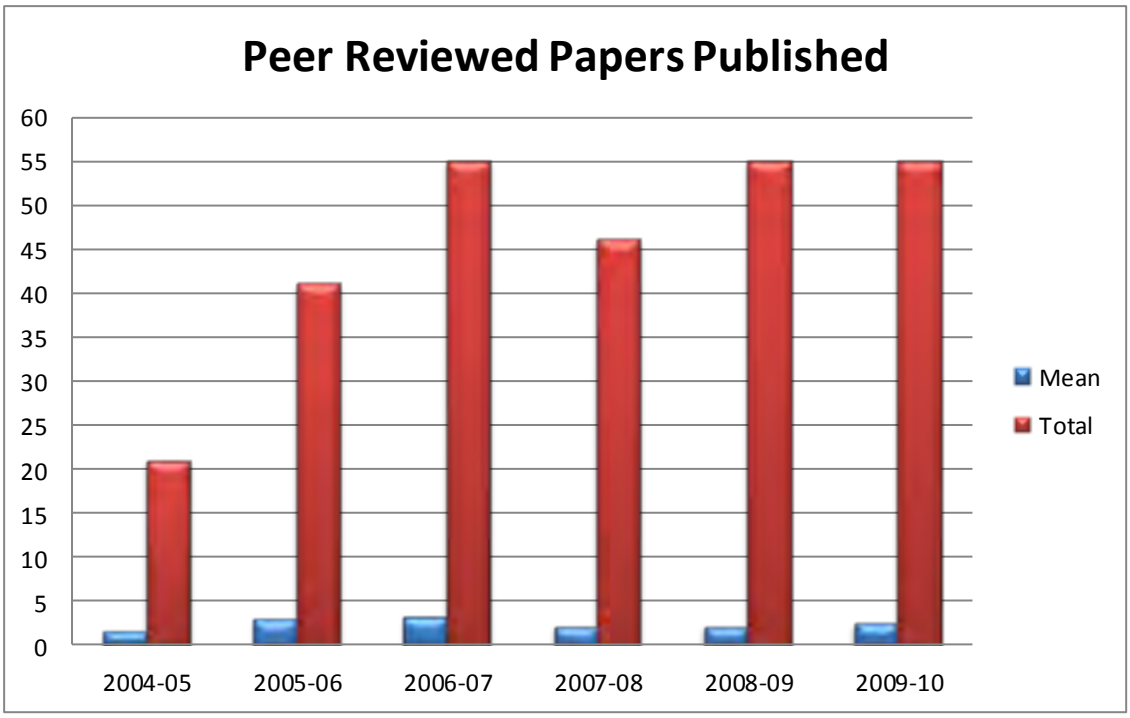


Specific examples of our activities include:

- Provide technical resources and discussion points to other Department of the Interior partners to assist in land management decisions such as opening of the Going to the Sun Road in Glacier National Park, elk management on DOI lands in Wyoming, and Asian carp eradication in the Great Lakes Region.
- Scientific review for various professional journals and interagency ecosystem management plans, as well as provide data and graphics for various publications such as technical reports, posters, brochures and multi-media outlets.
- Coordination of regional and National natural resource conferences and seminars.
- Provide mentorship and guidance to over 20 Masters and Doctoral students seeking a career in natural resource and ecosystem sciences.
- Provide data and research summaries to Congressional Delegates.
- Serve as invited speakers or panelist for national and international conferences and meetings.

Publications and Technical and FSP Review Activities

Our researchers published 55 peer reviewed journal articles in FY 2010. In addition our scientists provided over 130 reviews for technical publications. Examples include Journal of Wildlife Management, Forest Ecology and Management, Conservation Biology, Conservation Genetics, Environmental Monitoring and Assessment, Remote Sensing of Environment, Western North American Naturalist, Journal of the American Water Resources Association, Ecology, Ecological Monographs, Ursus, Molecular Phylogenetics and Evolution, Diversity and Distributions, Ecological Applications, Transactions of the American Fisheries Society, Climatic Change, and International Journal of Wildland Fire.



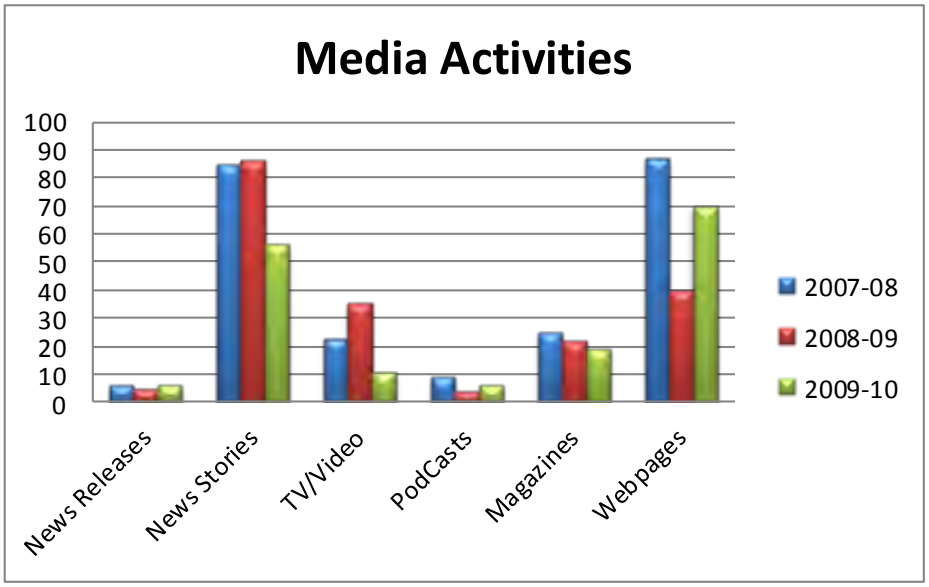
NOROCK Awards and Recognition

In 2010 our scientists received honors for excellence in research and development within their individual disciplines. Several staff received the USGS Performance Award and USGS Star Award. Other awards for 2010 include:

- Outstanding Wildlife Article Award, The Wildlife Society (Katherine Kendal)
- Central Region Diversity Award (Jackson Gross)

NOROCK in the National Spotlight

We produce a dynamic array of products based on our research which include information sheets, annual reports, journal articles, and books. The purpose of these resources is to provide information on the Center's wide range of research projects to both natural resource managers and the public. Our publications can be found in many public venues such as interpretive centers within the National Park Service, Forest Service, Bureau of Land Management, and academic institutions throughout the northern Rocky Mountain region. This chart summarizes our media activity for 2010.



USGS News Releases, Media Advisories

- 8/17/2010. Prestigious award granted to local grizzly bear researchers..
- 4/27/2010. Keeping Track of Grizzly Bears in the Northern Rockies.
- 3/29/2010. Elk Brucellosis infection may be increasing in the Greater Yellowstone Ecosystem.

2010 Publications:

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in the Anaxyrus boreas species group. Molecular Phylogenetics and Evolution 50:209–225.

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