U.S. Department of the Interior
Geological Survey

Northern Rocky Mountain Science Center

2008 Annual Report
(abbreviated)

TABLE of CONTENTS

The following document is an overview and summary of the science and research conducted at the Northern Rocky Mountain Science Center (NOROCK). We hope you'll find the information useful and if you would like to have reprints or copies of the publications listed, please feel free to contact us for more information 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 North Central Area of the Central Region 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 hosted by Montana State University which jointly co-sponsors the Mountain Prairie Information Network as part of the National Biological Information Infrastructure

Mission – The mission of NOROCK 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.

History and Overview

Brief History

The Northern Rocky Mountain Science Center (NOROCK) 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 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.

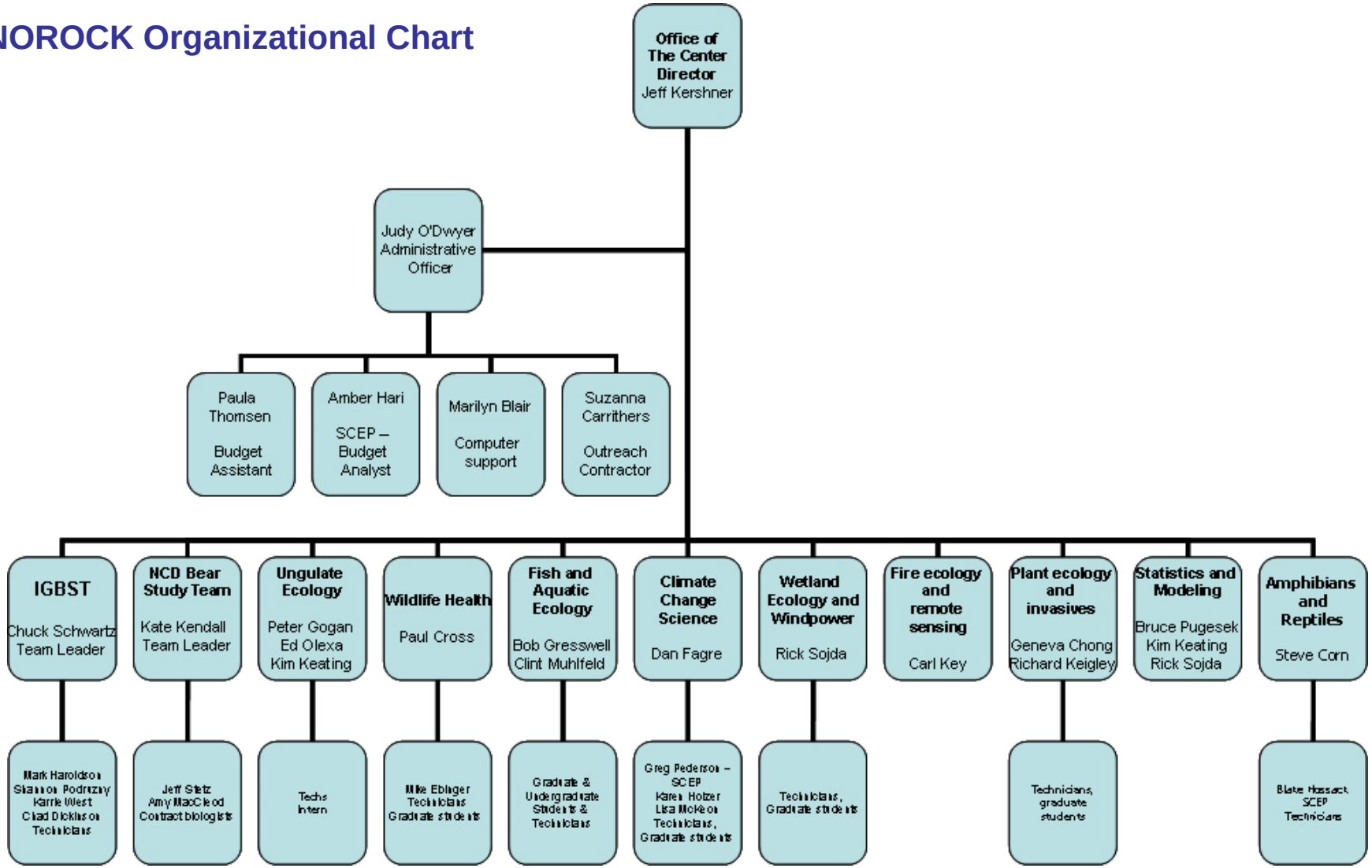
Current Staffing

- 35 Federal Staff
- 16 Research scientists
    - Ecologists, zoologists, wildlife biologists, aquatic biologists, statisticians, plant ecologists, and geographers
    - 2 SCEP doctoral students
- Science support
    - Biologists, biology and hydrology technicians, administration
        - 1 SCEP graduate student
- Others
    - Contract employees, university cooperators, post-doctoral associates

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, the U.S. Forest Service, the University of Montana, Montana Department of Fish, Wildlife and Parks, Wyoming Game and Fish Department, and Idaho Department of Game and Fish. Researchers also collaborate with numerous partners through the Interagency Grizzly Bear Committee, Greater Yellowstone Coordinating Committee, Greater Yellowstone Interagency Brucellosis Committee, Rocky Mountain Cooperative Ecosystem Studies Unit, Northern Yellowstone Cooperative Wildlife Working Group, Pacific Flyway Council, Montana Wetland Council, Big Sky Institute, 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 management decisions.

NOROCK Organizational Chart



Science Programs

NOROCK is located in the North Central Area of the Central Region of the U.S. Geological Survey (USGS). Science accomplishments of NOROCK are based on government goals specific to protection and conservation of natural resources and fall under specific programs. Below are the USGS biological science programs, other national programs, regional science thrusts and corresponding NOROCK projects.

ECOSYSTEMS

- Monitoring and ecological modeling of species and habitats with special emphasis on DOI lands in the Northern Rocky Mountains
- Climate Change in Mountain Ecosystems
- Understanding the effects of flow regulation on the Snake River Ecosystem below Jackson Lake: Using Science in an Adaptive Management Framework
- The use of radar to map bird migrations and migration corridors – with specific emphasis on potential wind farm development.
- Post-fire burn assessment by remote sensing on National Park Service lands
- Geologic studies of the Greater Yellowstone Ecosystem

INVASIVE SPECIES

- Anthropogenic encouragement of non-native species: impacts of fuel treatments and post-fire rehabilitation activities
- Monitoring and ecological modeling of species and habitats with special emphasis on DOI lands
- Wyoming Landscape Conservation Initiative

FISHERIES: AQUATIC & ENDANGERED RESOURCES

- Species, population, and habitat assessments for native salmonids in the Northern Rocky Mountains.

NATIONAL GEOSPATIAL PROGRAM

- Building the National Spatial Data Infrastructure

WILDLIFE: TERRESTRIAL & ENDANGERED RESOURCES

- Assessing the distribution and effects of disease on amphibians in the Northern Rocky Mountains.
- Conservation requirements for wild ungulates of the Northern Rocky Mountains
- Science to support management of wildlife diseases in the Rocky Mountains and Africa Plains.
- Modeling disease dynamics in structured populations
- Assessing the condition and trend of browse communities
- Effect of browsing following wildfire.
- Conservation requirements for wildlife of the Northern Rocky Mountains: The Interagency Grizzly Bear Study Team
- Conservation requirements for wildlife of the Northern Rocky Mountains: The Northern Continental Divide Grizzly Bear Project
- Sage grouse habitat relationships, Jackson, Wyoming

CLIMATE CHANGE PROGRAM

- Potential impacts of climate change on ungulate species in the Northern Rocky Mountains.
- Potential impact of climate change on native salmonids

CENTRAL REGION INTEGRATED SCIENCE PROGRAM

- Integrated science to understand lake and wetland ecosystems of the Northern Rocky Mountains

NOROCK Research Emphases

The Conservation of Amphibians, Fish, and Wildlife of the Northern Rocky Mountains

The Northern Rockies are blessed with an abundance of plant and animal species which have remained relatively intact since the Lewis and Clark expedition in the early 19th century. Large, charismatic species such as wolves and grizzly bears still inhabit many areas and free roaming ungulates are still very much part of the landscape. Native amphibians, fish and reptiles are still present in their historic ranges for the most part, but challenges to the conservation of these species are numerous. Energy development, increasing human population pressures, and the continued demand for more water make the management of wildlife more complicated than ever. Scientists at NOROCK work with partners to study key life history and habitat needs of these species. We develop analytic tools that help managers with decision support to evaluate the tradeoffs of various management options.

The Changing Landscape of the Northern Rocky Mountains

Unprecedented population growth, the re-emergence of the energy industry, and the increasing demand for water and natural resources is changing the landscape of the Rockies. Couple that with global climate change, and managers face unprecedented challenges in the management of natural resources. Center scientists are working on research projects that will provide managers with information related to the effects of climate change on glaciers and ecosystems, the consequences of flow regulation on aquatic and riparian resources, and the influence of geology and hydrology on the dynamics of wetland ecosystems. We study the effects of invasive species on terrestrial and aquatic systems, and track the effects of large-scale energy development on the sagebrush ecosystems of the northern Rockies. The changing dynamics of wildfire in the northern Rockies are also a concern of natural resource managers.

Modeling Complex Systems and Decision Support - An Emerging Need

Wildlife species assessments synthesize data from many sources that may use different methods, have different data, and often encompass multiple time periods. Tools are needed to integrate this information to determine the ecological effects of land management on both public and private lands. The increasing pressure of land development on private 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. We are developing models that use this information to display the effects of management alternatives on the resource goals identified by managers and the public. Decision support systems are relatively new techniques to use information from research studies to develop models that display the consequences of various management alternatives. Model inputs can be adjusted to fit management goals or environmental conditions to display the effects on the system so that managers can weigh tradeoffs of different management options.

The Conservation of Amphibians, Fish, and Wildlife of the Northern Rocky Mountains - Highlights

AMPHIBIANS

Assessing the distribution and effects of chytrid fungus on amphibians in Grand Teton National Park. The objectives of NOROCK researchers and their partners were to determine the effects of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), on the health and survival of boreal toads and map the distribution of the chytrid fungus prevalence of chytridiomycosis in Grand Teton National Park. Bd infects the frog's skin and may cause problems in respiration or other effects, and is suspected as a leading cause of global amphibian declines. The pathogen Bd was present in breeding adult boreal toads at all 10 sites sampled, with a mean prevalence of 67%. Additional experiments also suggest that although widely infected in nature, Wyoming boreal toads may escape chytridiomycosis due to a slight advantage in innate resistance or because their native habitat hinders Bd growth or provides more opportunities to reduce pathogen loads behaviorally than in Colorado. Results of this study are in press in the journal *Ecohealth*.

BIG GAME SPECIES AND WILDLIFE DISEASES

Analysis of changing elk demographics and disease dynamics across the Greater Yellowstone Ecosystem. NOROCK scientists and their partners are examining elk demographic and disease dynamics in Wyoming, Idaho and Montana. This work spans three states; with almost 4000 disease tests over 20 years, and census data from 1946 onwards. So far the study team has showed that some elk populations far from both bison and feedgrounds now appear to be viable reservoirs of brucellosis, sustaining levels not previously seen in elk. The number of that elk tested positive for brucellosis in the study population, known as seroprevalence, increased over time in four of five Wyoming elk herd units for which there are sufficient data. These changes in brucellosis correspond with elk counts in each herd unit, with one exception. Model simulations suggest that these seroprevalence levels cannot be sustained only by dispersal of elk from the supplemental feedgrounds where seroprevalence is high (~33%). Limited disease data existed for Montana, but some of Montana's elk populations were five to nine times larger in 2007 than in the 1970's and are comparable to the Wyoming populations with higher levels of brucellosis. In addition, by 2007 some Montana elk experienced group sizes similar to the supplemental feedgrounds in Wyoming.

NOROCK big game research is not limited to the Northern Rocky Mountain region. Two projects in Kruger National Park, South Africa, are studying 1) The effects of bovine tuberculosis (BTB) on the African buffalo population and 2) sexual segregation in African buffalo. Partners in this study include University of Pretoria, Kruger National Park, Agricultural Research Council, and USGS National Wildlife Health Center.

Modeling species occurrence in space and time. Widely used to describe an animal's relative frequency of occurrence in 2-dimensional space, utilization distributions (UDs) have been a cornerstone of home range studies for over 30 years. Extending the UD concept to include frequency of occurrence in space and time, NOROCK scientists have devised a new modeling method to give resource managers better information about patterns of occurrence and how those patterns change over time. The increased information made possible by this method is illustrated through computer simulations, and in an example model showing seasonal changes in the expected UD for bighorn sheep (*Ovis canadensis*) in Glacier National Park, Montana. A paper describing this work is expected in *Ecology* in 2009, together with videos showing the kinds of time-dependent models made possible by this method.

GREATER YELLOWSTONE ECOSYSTEM BEAR STUDIES.

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). Information gathered and analyzed annually by the IGBST is used to assess population trend and help focus management activities toward issues that impact bears.

In 2008, counts of unique females with cubs of the year (FCOY) include the following: 1) minimum number of unique females with cubs of the year (FCOY) identified during 2008 was 44; 2) excluding the families identified only via telemetry, the estimate for total number of FCOY was 56; 3) model-averaged estimate for FCOY indicates a continuing positive trend for this segment of the population; and 4) population estimate derived from the model-averaged FCOY was 596 grizzly bears.

IGBST documented 41 known and probable mortalities in the ecosystem as of October 2008. Total reported plus estimated unreported bear mortalities were within sustainable levels for independent aged (≥2 years) females, but was exceed for males. Human-caused mortalities of dependent young (<2 years) was <15% of their estimated numbers.

IGBST also monitors and collects key food data throughout the ecosystem. 2008 surveys include: 1) spring carcass surveys on Yellowstone National Park ungulate winter ranges averaged 0.43 carcasses/km; 2) whitebark pine cone production transects average 8.2 cones/tree; 3) levels of tree mortality on transect trees alive in 2002 is 56.8%, and 94.7% of transects contain beetle killed trees; 4) researchers observed 297 grizzly bears on 26 (51%) of the 51 confirmed and possible moth aggregation sites.

NORTHERN CONTINENTAL DIVIDE ECOSYSTEM BEAR STUDIES

The Northern Continental Divide Ecosystem (NCDE) in northwest Montana is one of the last strongholds of the grizzly bear in the lower 48 states. 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. In 2008 NOROCK's Northern Divide Grizzly Bear Project (NDGBP) completed a study that provides a better understanding of the population size, distribution, and genetic health of grizzly bears in northwest Montana.

Noninvasive DNA studies to determine grizzly bear populations. This study is the largest non-invasive study of bears to date and is the first ever ecosystem–wide scientific assessment of grizzlies in the 12,187-square-mile Northern Continental Divide area. During the 2004 summer field season, 4,795 bear rubs and 2,558 hair traps were used to collect hair. Approximately 13,000 samples were collected from bear rubs and 21,000 were collected from hair traps, providing researchers with a total of 34,000 bear hair samples. NOROCK scientists then used statistical models to calculate the number of bears not sampled and incorporate them

into an estimate of the total population size, leading to a complete population estimate of 765 grizzly bears making their home in the NCDE.

The Remote Camera Project Is a secondary output of the NDGBP project which used remote video and still cameras that captured numerous wildlife species throughout the NCDE. These video and still shots were used to investigate: how grizzly bears, black bears, and other wildlife species respond to baited, barbed wire hair traps; bear use of naturally-occurring bear rubs, bear marking behavior, and effects of putting barbed wire on bear rubs to facilitate hair collection; and how hair traps may be modified to improve detection probabilities. Not only has the remote camera footage been invaluable to researchers, it has also peaked the interest of the general public. Remote camera footage has been posted on NOROCK's website enabling web viewers to see various wildlife species in their natural habitat that may otherwise never be seen by humans.

NATIVE FISHES OF THE NORTHERN ROCKIES

Abiotic and biotic factors structuring the spawning and seasonal distribution patterns of Finespotted Cutthroat Trout in the Snake River, Grand Teton National Park, WY. The finespotted Snake River cutthroat trout is generally perceived as a morphologically divergent ecotype of the more broadly distributed Yellowstone cutthroat trout. Although there is a popular sport fishery focused on this native trout, spawning and distribution patterns in the historical range are poorly understood. Consequently, it is difficult to predict how future disturbances (e.g., climate change or an increase in the prevalence of nonnative species) may affect behavior or persistence. To identify spawning patterns, 49 radio telemetry tags were implanted in cutthroat trout during September and October, 2007, and fish were tracked weekly from May, 2008 through the spawning season. Significant temporal and spatial variability in spawning behavior was expressed by the 22 fish that made distinct spawning migrations. Spawning was observed in the mainstem and side channels of the Snake River, several tributaries, and three major spring creek complexes. Although the majority of this spawning activity occurred within 40 km of the fish's capture location, three fish migrated to spawning areas 75-100 river kilometers away. In September and October, 2008, an additional 199 cutthroat trout were implanted with radio telemetry tags. These fish will be relocated every two months in the winter until May, when weekly tracking resumes through the spawning season. Ultimately, understanding the behavioral variability of finespotted cutthroat trout, the physical and biological variables that influence distribution patterns, and the habitat connectivity required to complete the life cycle, will provide new insights into the management of this portion of the Snake River.

NOROCK fisheries research is not limited to the Northern Rocky Mountain region. Two projects in the Columbia Basin are studying 1) how landscape feature influence diversity in Oregon cutthroat trout and 2) evaluating the management objectives used to assess stream habitat conditions on federal lands within the Interior Columbia Basin.

The Changing Landscape of the Northern Rocky Mountains

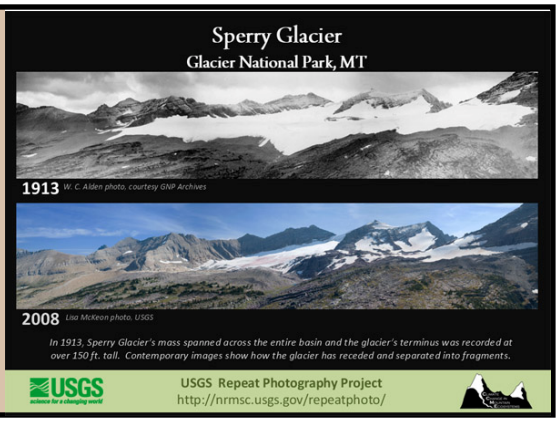
MOUNTAIN ECOSYSTEMS

Declining snowpack in west. Snow shapes the landscapes and economies of the western United States and the decline in snow pack, and resulting ecological implications, are still not fully understood by researchers. To address this, NOROCK and their collaborators use tree-rings to reconstruct snowpack over several centuries for three key high-mountain areas: the Upper Colorado River Basin, Upper Yellowstone/Missouri River Basin, and the Columbia and Saskatchewan River Headwaters. The resulting high-resolution maps of past snowpack will be used to understand how ocean sea surface temperatures (e.g., El Niño, Pacific Decadal Oscillation) influence snowpack in the west. This question is particularly important in sorting out the degree to which current trends are 'natural' vs. resulting from human-caused changes in climate. This project will also develop tools for water managers to assess how variability in snowpack affects resource management. The work is particularly relevant as the three target ranges form the headwaters for the west's three most important watersheds, the Colorado, the Yellowstone/Missouri and the Columbia. In order to calibrate tree-ring data to snowpack data, researchers have assembled large spatial databases using existing tree-ring chronologies and records of April 1st snow water equivalent (SWE) in the headwaters of our three target watersheds. Preliminary results indicate that the tree-ring reconstructions faithfully capture the decade-scale variability in 20th century snowpack.

Climate Change in Mountain Ecosystems.
NOROCK's Climate Change in Mountain ecosystems program (CCME) has 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 has led to mountain research networks to expand our understanding of how mountain ecosystems respond to climate change.

The Repeat Photography Project. Since 1997 over seventy photographs of nineteen different glaciers have been repeated. Thirteen of those glaciers have shown marked recession and some of the more intensely studied glaciers have proved to be just 1/3 of their estimated maximum size that occurred at the end of the Little Ice Age (circa 1850). In fact, only 26 named glaciers presently exist of the 150 glaciers present in 1850 and those that do are mere remnants of their previous size. Repeat photography has become an important tool for documenting and analyzing the retreat of glaciers and the images have garnered much interest from the media, academia, and most recently from the art community. Incorporating repeat photographs and climate change research with art has become a new thrust for the Climate Change in Mountain Ecosystems (CCME) program in an effort to communicate research findings with new audiences. Recent art collaborations have included working with musicians, sculptors, poets, and a local art gallery to create an exhibit of repeat photographs.

Glacier mass balance studies on Sperry glacier, an index glacier in Glacier National Park, confirm that the glaciers will likely all be gone by 2030 as predicted by a model. Sperry is presently 0.841 km2 - 22% of its mid nineteenth century estimated area of 3.87 km2. It's diminished at 0.11 km2 in the past decade at an annual rate of 0.013 km2 (12700 m2/yr) or ~1.2% per year. Sperry shrank most dramatically in the early part of the century. The annual rate was 10-20x faster. It's declined since then, partly because it's pulled back in to the flatter, shaded cirque. At present rates of melting, Sperry will be gone in 22 years but the appearance of rock islands and collapse of ice from a cliff band during this past year will alter the albedo and likely accelerate melting.



FIRE SCIENCE

Effect of browsing following wildfire in the Missouri Breaks, Montana. The purpose of this study is to determine if browsing following two wildfires will prevent young plants from attaining their potential stature. One fire occurred in 2003, the other in 2006. It was determined that skunkbush will likely attain potential stature while chokecherry will not. Chokecherry is an important habitat component and by documenting its decline, this study may influence the setting of stocking rates, big game harvest levels, and the establishment of habitat. In addition, data indicate that weather conditions that occur during the late-Spring of the initial growing season may be an important determinant of the height to which plants ultimately grow.

This study also addressed the question of when certain browse evaluation techniques may be appropriate. A new method based on an analysis of growth rate was developed to assess potential growth of chokecherry during the early years following fire. Browsing level and LD Index data collected in 2008 corroborated the predictions based on 2007 growth rate data. It was determined that for the initial four years, an analysis of growth rate is the more appropriate method. After five years, browsing level and LD Index provide a better method of associating the effect of browsing on potential changes in structural diversity.

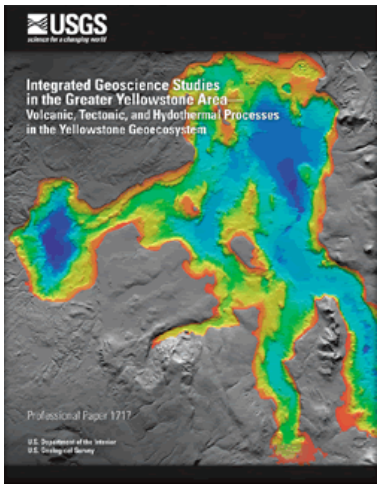
USGS-NPS Burn Severity Mapping. Remote sensing and field sampling techniques to support national assessment of burned areas was under development from the mid-1990's by collaborators at USGS and National Park Service. At the time, there was no standard approach to broadly quantify and spatially represent burn severity or the ecological effects of fire within the NPS. Researchers pursued a number of strategies to initiate a national program for burn severity mapping and monitoring within NPS and USGS. Current emphasis at NOROCK is to complete a publication on evaluation results across the U.S., to demonstrate useful applications of the extensive data holdings, and to derive new information on trends and the landscape ecology of fire.

Monitoring Trends in Burn Severity-MTBS. In June 2004, the Government Accountability Office (GAO) recommended that all federal land management agencies adopt the USGS-NPS burn severity mapping protocol as a monitoring mechanism to assess fire effects and broader wildland fire patterns and trends. Soon after, the Monitoring Trends in Burn Severity (MTBS) was established. The main goal of MTBS is to generate standard, comparable data to monitor fire trends and management effectiveness on a national level, in contrast to direct emergency response applications. Current products are based on Landsat imagery and the dNBR obtained

during the growing season after fire for an extended assessment on most burns. In addition, investigations that use the burn severity time-series in landscape and fire ecology are of interest, including relationships to climate, trends and modeling of fire behavior, and responses of vegetation and wildlife. Current MTBS outputs include instructional materials and guidance, training and assistance in field sampling, creation of a photo series of the burn severity continuum in key ecosystems of the U.S., and scientific or technical leadership and review of procedures and products.

GREATER YELLOWSTONE ECOSYSTEM – PRIORITY ECOSYSTEM SCIENCE

Glaciation of the Yellowstone area. In a recently published paper. NOROCK researchers and their partners discuss the chronology of Yellowstone glaciation. Penultimate glaciation, the next-to-last glacial period in Yellowstone, extended tens of kilometers beyond the last glaciation to the south, southwest, and west of Yellowstone and culminated about 140,000 years ago. During the last glaciation, glaciers flowed outward from Yellowstone and their culmination was older in the northeast and younger in the south: ~19,000 years ago in the northeast, ~16,500 years ago in the north, and 14,000 to 15,000 years ago in the south. This age progression may be explained by building of the Yellowstone glaciation progressively to the southwest in the direction of the moisture source for air masses funneled up the eastern Snake River Plain.



INVASIVE SPECIES AND VEGETATION CHANGE

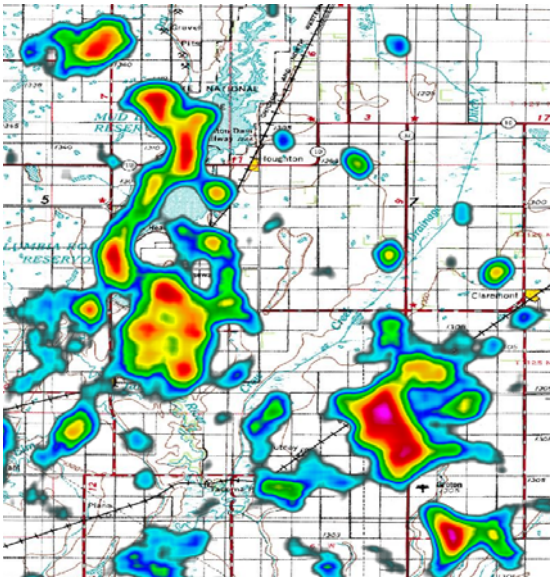
Wyoming Landscape Conservation Initiative. The WLCI is a long-term science based effort to enhance aquatic and terrestrial habitats at a landscape scale in Southwest Wyoming, while facilitating responsible development. The USGS Science Planning Team is working with the multi-agency WLCI Coordination Team to design the science framework for long-term and effectiveness monitoring. Effectiveness monitoring activities conducted by NOROCK in 2008 were located in the Pinedale Anticline and the Rock Creek Allotment were researchers and interns selected and sampled vegetation. Products from this project include an MSAccess database and digital photos for each plot.

LAKE AND WETLAND ECOSYSTEMS

Wetland ecology and management. NOROCK's wetland ecology research has completed a final year of data collection at Red Rock Lakes NWR and researchers have begun some multivariate time series analysis of the hydrologic data in collaboration with statisticians at Montana State University. Researchers plan to apply these methods to similar data from prairie pothole wetlands, where they are now monitoring groundwater in almost 30 palustrine, seasonal basins. Because of close collaboration with biologists from the USDI-Fish and Wildlife Service, this project is morphing into one where scientists will apply knowledge of wetland ecology and groundwater movement to understanding the change in oil brine plumes from energy development in the Bakken Oil Field. Questions being posed by managers focus on the risk to wetlands on Waterfowl Production Areas from the potential sources of contamination.

Modeling Complex Systems and Decision Support - An Emerging Need

Radar ornithology. The tremendous growth in the wind energy industry has increased the value of NOROCK's work related to identifying birds in Doppler weather radar, also known as NEXRAD. Researchers have begun to develop field methods for surveying the three dimensional location of Canada geese and lesser snow geese at migration stopover sites like Horicon NWR (WI) and Freezout Lake Waterfowl Management Area (MT). This year, NOROCK researchers presented preliminary results at both international conferences and at national wind energy workshops. The work this year focused on developing partnerships with the National Renewable Energy Lab and Montana State University to use machine learning algorithms to successfully identify flocks of migrating birds. This work is in collaboration with the Upper Midwest Environmental Sciences Center and has begun to spawn additional research efforts to develop decision support systems for evaluating the effects of wind energy development on birds staging at migration stopovers.



Lesser snow geese (brighter colours) moving back to Sand Lake NWR as depicted on NEXRAD weather radar.

Modeling habitat-specific probability of occurrence for grizzly bears (Ursus arctos) in the Greater Yellowstone Ecosystem. Limiting human-caused mortalities is key to grizzly bear conservation in the GYE. To help manage mortalities, recent work at NOROCK has focused on developing a spatially explicit hazard model to better identify high-risk areas where mitigation measures might be most effective. Such a model requires two major components: one sub-model to predict probability of mortality at particular locations, and another to predict probability of use. Areas where the probabilities of mortality and use are both high would be prime candidates for mitigation measures. The first of these models was recently completely, providing spatially explicit estimates of probability of bear mortality based on relationships that show grizzly bear survival increases with secure habitat and elevation, but declines with road density, numbers of homes and site developments, and ungulate hunting activity. This study aims to model probability of occurrence of grizzly bears, thereby enabling construction of an overall hazard surface for Yellowstone grizzly bears.

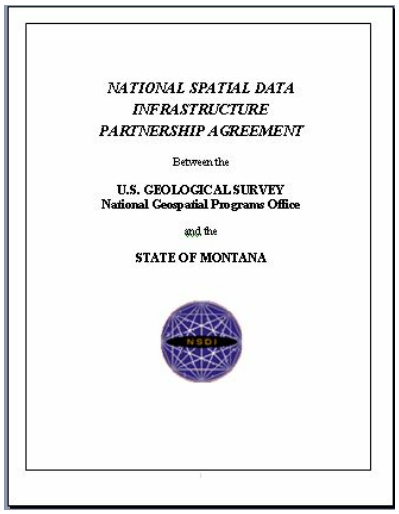
Predictive use of non-linear and structural equation modeling. NOROCK researchers use non-linear modeling in identifying years for which there exists an increased likelihood for climatic events that are severe enough to impact food production and disease pandemics. Results open

a new avenue for research regarding climate change and earth change events such as volcanism. Furthermore, research indicates years in which preparations for disease pandemics at the national and international level should be targeted. Structural equation modeling is used for modeling riparian data which will provide guidance to the National Park Service and Bureau of Reclamation for release of water at Jackson Lake Dam in a manner that is most conducive for managing the riparian ecosystem below the dam. NOROCK researchers also use structural equation modeling is also used for modeling BLM Bugs data proceeding which will provide example of scientific analysis of archived database. Results will provide initial steps aimed at developing a systems analysis for comparisons of managed and refernced habitats.

Relationship of crab abundance to Whooping Crane success. Tenth year of data collection provides additional data points on the relationship of crab abundance at the wintering area to Whooping Crane survival and reproductive success. Blue crab abundance is inversely related to Whooping Crane survival. Results of the study have been instrumental in the State of Texas' action to create a moratorium on commercial crabbing in the Aransas refuge area. Results may also play a role in the continuing debate and litigation concerning upstream uses of fresh water and its impact on the estuarine environment surrounding the Aransas Matagorda-Island National Wildlife Refuge.

National Geospatial Program

The U.S. Geological Survey (USGS) Geospatial Liaison to Montana is part of the National Geospatial Program Office (NGPO) supporting the geospatial community in Montana through the Northern Rocky Mountain Science Center located in Bozeman, Montana. The Geospatial Liaison works with partners to build the National Spatial Data Infrastructure (NSDI) through geospatial coordination, partnerships, leadership and guidance.


NATIONAL SPATIAL DATA
INFRASTRUCTURE
PARTNERSHIP AGREEMENT
Between the
U.S. GEOLOGICAL SURVEY
National Geospatial Programs Office
and the
STATE OF MONTANA

2008 Agreements:

University of Montana – National Center for Landscape Fire Analysis - GNIS Project. Correct inconsistencies in the GNIS to support MT Wildland Fire Base Map, establish GNIS as formal framework layer for MT, establish GNIS stewardship through State Names Advisor, define future needs for a state names database and stewardship of the GNIS

State of Montana – Department of Administrative Services - Structures Project. Research procedures and process to derive structures point data from state ownership parcel data. Produce structures data to support NSDI critical structures in Montana

State of Montana – Montana State Library, Natural Resource Information System – NHD Stewardship. Build, maintain, update, and improve the NHD in Montana under a long-term data stewardship program. Supports consistent / long term stewardship of the NHD

NGTOC – Support for the maintenance and stewardship of the National Wilderness Preservation Boundaries dataset. Support the maintenance of the National Wilderness Preservation Boundaries dataset as a national data resource.

New Projects in 2008

In 2008 NOROCK researchers were awarded approximately $3.3 million in grant funding to support ongoing and emerging research in and around the Northern Rocky Mountains.

Implications of mining on native fish in the Transboundary Flathead. Research conducted by NOROCK and several partnering agencies demonstrates that the Transboundary Flathead Basin in Montana (USA) and British Columbia (Canada) is a stronghold for native trout, including the threatened bull trout and state sensitive westslope cutthroat trout. However, the Canadian headwaters are targeted for coal-bed methane (CBM) drilling and open-pit coal mining, threatening water and habitat quality, migratory fish populations, and all aquatic life downstream to Glacier National Park (GNP) and Flathead Lake. NOROCK is leading an international aquatics research project to assess the distribution, abundance, life-history, and genetic characteristics of native fishes in GNP and the Canadian portion of the drainage over the next five years. These baseline data will be used as a reference point for long-term population and habitat monitoring prior to potential mining or CBM development.

The potential impacts of climate change on native aquatic ecosystems of the Northern Rocky Mountains. State and federal agencies and non-governmental organizations are increasingly consumed with the recovery and restoration of native trout and salmon throughout the western United States. Complicating these issues is global warming and associated climate change and understanding how effects of climate change will influence habitat for native fish is critical for effective management and recovery of these species. NOROCK scientists and their partners are examining how climate change may be impacting the habitats of native trout throughout the Rocky Mountains and the interior western United States. The goal is to provide tools that will help managers predict potential climate change induced impacts on native fish. By developing these types of tools, researchers can assist managers in predicting potential climate change induced impacts on salmonid species throughout the Rocky Mountains.

Study examines impacts of climate change on wildlife in the Northern Rocky Mountains. The ecology of hoofed big-game species in the northern Rocky Mountains, known as ungulates, is strongly influenced by climate. Climate change impacts summer precipitation, winter snow pack, and the timing of spring green-up, all of which control animal physiology, demography, diet, habitat selection, and predator prey interactions. However, the degree of response to these impacts from animals such as elk, moose, mule deer, and pronghorn antelope is uncertain. NOROCK and their collaborators will study how global climate change may impact ungulate species. The long term goal of the project is to provide the tools for natural resource managers to facilitate a better, science-based understanding of how climate change can impact various ungulate species within the region.

Composite Burn Index (CBI) Photo Series. The Composite Burn Index is a field rating of burn conditions averaged over a forest location ranging from 0.0 to 3.0. It is based on averaging 4-5 rating factors within Understory (A. - C.), Overstory (D. - E.), and over all strata (A. - E.) to rate the Total Plot. The CBI Photo Series shows burn conditions taken from field plots along a gradient of fire impact. Representative plots were selected where photos and data illustrated composite site-effects at intervals of severity. Examples offer a means to calibrate field interpretations, and display the variety of stratum responses contributing to overall ratings. This also illustrates the difficulty in applying burn severity categories or labels. NOROCK is currently developing the CBI Photo Series website which will be a comprehensive collection of CBI photo series based on geographic location and include supplemental, informational fire photos.

Climate impacts on burn severity in three forest ecoregions of the U.S. The historic range of variability in burn severity, as it relates to climate, is a critical missing link in current understanding of fire-climate relationships. This study aims to determine how climate variability, trends and teleconnections contribute to landscape heterogeneity of burn severity across three representative forest ecosystems of the western U.S. including areas surrounding Glacier National Park in Montana, Yukon-Charlie Rivers National Reserve in Alaska, and Yosemite National Park in California. Building upon past and current research and applications within USGS, other DOI agencies, and the USFS, the study spatially quantifies burn severity through Landsat remote sensing, and uses available climate data to address three scientific questions: 1) how does climate variability (e.g. seasonality, temperature, precipitation) manifest spatiotemporally in patterns of burn severity; 2) how do climate teleconnections manifest spatially and temporally in large area patterns of burn severity; and 3) to what extent can we generalize impacts and trends in burn severity across the three representative western U.S. ecoregions; how are they similar, how do they differ? Overall, results will lead to understanding how climate controls burn heterogeneity and subsequent fire effects in western U.S. forest ecosystems.

NOROCK Technical Assistance Activities

ADVISORY AND CONSULTATION

In 2008 NOROCK researchers served in the capacity of science advisor or technical consultant on approximately 80 occasions to federal, state, or private organizations. Examples of this service included:

- Advised USDA Forest Service researchers on science design issues for a black bear population abundance study in the Lake Tahoe basin, California.
- Rock Creek Allotment, Kemmerer Field Office: selected sample sites in the Rock Creek Burn (west side of Fossil Butte National Monument) and trained two Chicago Botanical Garden interns in multi-scale vegetation sampling.
- Multiple consultations with the National Elk Refuge Wildlife Biologist and Refuge Manager regarding vegetation, sage-grouse, invasive species, opportunities for funding/collaboration, etc.
- Expedition Team scientist for Extreme Ice Survey project with photographer James Balog. Sponsored by National Geographic Expeditions Council, National Science Foundation and numerous other organizations. http://extremeicesurvey.org/
- Canadian Wildlife Service. Guidance on a document addressing grizzly bear recovery in the Canada prairie region, Sask, Manitoba, Alberta.
- The Wildlife Society. Technical review of predator control plan.
- Provided consultation to Blackfeet Tribal Fish and Game authorities regarding bighorn sheep harvests on Tribal lands (joint meeting with Glacier National Park and the Blackfeet Fish and Game Agency, Browning.
- Swiss Federal Research Institute WSL, Birmensdorf, Switzerland, on use of the Composite Burn Index (CBI) for field sampling of burn severity, active research.
- Australia Department of Environment and Conservation, Science Division, on burn mapping approaches in Australia, active management.

TECHNICAL PUBLICATIONS OR USGS FSP REVIEW
NOROCK researchers served as reviewers for approximately 40 technical publications including the following: Journal of Wildlife Management, Conservation Biology, Conservation Genetics, Environmental Monitoring and Assessment, Remote Sensing of Environment, and International Journal of Wildland Fire.

GRADUATE ADVISORS
NOROCK researchers served as advisor for approximately 30 graduate students at the following institutions:

- Montana State University
- University of Montana
- University of Arizona
- Oregon State University
- University of Wyoming
- Utah State University
- University of Minnesota
- Colorado State University
- University of Reno
- Washington State University

NOROCK Awards and Recognition

In 2008 four NOROCK scientists received honors for excellence in research and development within their individual disciplines.

Technical Writing
Rick Sojda, NOROCK wildlife biologist, received an award for the best decision support paper (2007) from the journal, *Environmental Modeling and Software*. As described by the journal's Editor-in-Chief, the aim of the awards is to recognize those authors whose papers epitomize the aims and scope of the journal. The certificate of award was presented at the 2008 Congress of the International Environmental Modeling and Software Society in Barcelona, Catalunya (Spain)per was joined by two other papers and authors from around the world who were recognized in the categories of integrated modeling, and generic modeling and software.

Bear Research
USGS wildlife biologists Mark Haroldson, Katherine Kendall, and Chuck Schwartz were awarded the *Scientific Leadership Award* by the Interagency Grizzly Bear Committee (IGBC) for their individual contributions to the study and conservation of bears in both the Greater Yellowstone and Northern Continental Divide Ecosystems.