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# INTRODUCTION

The U.S. Geological Survey (USGS) serves the nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life.

As the primary science agency for the US Department of the Interior (DOI), USGS emphasizes: 1) science excellence that focuses on high quality and independent science, using an integrated approach to research and 2) research that has societal relevance, where understandable science outcomes are communicated to decision makers and partners of interest with products, models and applications that are useful.

USGS also collaborates with a number of other partners, including states and local governments, universities, Non-government organizations (NGOs), and private sector science interest, and has enjoyed a long, productive relationship with the Western Association of Fish and Wildlife Agencies (WAFWA).

Listed below are highlights of research conducted in the Western United States by USGS scientists in our Biology, Geography, Geology, and Water Resources disciplines. Because this is not a comprehensive list of our research projects, you are encouraged to visit our web site ([www.usgs.gov](http://www.usgs.gov)) for additional information on all aspects of our research. If you have questions, or for more information on these or other studies, please contact Anne Kinsinger at (206) 220-4600 or [akinsinger@usgs.gov](mailto:akinsinger@usgs.gov)

# SUMMARY OF PROGRAMMATIC RESEARCH ACTIVITIES

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## WILDLIFE

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**U.S. Bat Populations:** USGS biologists completed the compilation of a nationwide database on historical counts of bats in colonies, analyzed the information for trends, and published a synthesis on the status and challenges in monitoring bat populations in the U.S. and Territories. USGS bat biologists are also preparing a synthesis document intended for resource managers that reviews existing ecological information pertinent to bat management and conservation. The emphasis is on those bats in the U.S. and territories that are considered species of concern by many management groups.

**Bats and Wind Power:** USGS scientists are involved in a collaborative effort to monitor and better understand the impact of wind turbines on bats. This involvement stems from previous successful efforts by USGS scientists to study migration in the group of bat species most frequently killed at wind turbines.

**Bat Conservation:** Conservation studies of endangered long-nosed bats in New Mexico: USGS researchers are studying the distribution, phenology, and status of potential food plants and interactions of bats and plants for three species of bats (Mexican Long-Tongued Bat, Lesser Long-Nosed Bat, and Greater Long Nosed Bat).

**Reestablishment of Utah Prairie Dog Populations:** Although methods for translocating Utah prairie dogs have been refined over the past 25 years, post-release loss rates remain high at many sites, and persistence of populations is low. USGS biologists are testing methods to improve the short-term retention and survival of prairie dogs at release sites, including visual barrier fences and electric fencing to temporarily restrict the post-release movements of prairie dogs, and artificial burrow structures and mowing to increase the attractiveness of sites to prairie dogs. Additional longer-term studies are being conducted to investigate effects of plague and habitat quality on population attributes.

**Studies on the Ecology of Southwestern Desert Grassland Birds:** Studies include (1) evaluating habitat needs (vegetative structure and composition) of wintering grassland birds and their response to management practices such as grazing (southeastern Arizona); (2) investigating the response of wintering grassland birds and grassland structure to a large wildfire (Ryan Wildfire, April 2002) and making comparisons with data gathered pre-fire (southeastern Arizona); and (3) determining breeding distribution and abundance of the Arizona Grasshopper Sparrow (southeastern Arizona and southwestern New Mexico), with an eye toward future expansion into more intensive breeding ecology studies on this subspecies.

**Southwest Amphibians:** USGS scientists are doing considerable work on how non-native species, such as the bullfrog, are affecting native amphibians, especially on National Wildlife Refuges. We

are also working on methods to control bullfrog populations and thus protect native species in southern Arizona. In addition, surveys are being conducted on the Colorado Plateau to determine the status and distribution of declining native leopard frogs.

**Amphibian Research and Monitoring:** There is a wide variety of work being conducted USGS in support of the Amphibian Research and Monitoring Initiative (ARMI). Besides the monitoring according to standard protocols (both local and regional), there are site specific studies to address critical questions, including 1) Spotted Frog Translocation for the Bureau of Reclamation; 2) Effects of Cattle Grazing and Related Habitat Attention on Columbia Spotted Frog Population; and 3) a Survey of Western Toad and Columbia Spotted Frog in the Great Basin.

**Describing Bird Migration Patterns in the Arid Southwest Using NEXRAD Weather Radar:** Through a cooperative agreement, USGS scientists and University of Southern Mississippi faculty are initiating a new collaborative study using NEXRAD Surveillance Weather Radar to understand bird migration patterns in the borderlands area of the arid Southwest. Objectives are to (1) map radar beam obstruction caused by ground clutter; (2) estimate geographic variation in migrant density during flight across the Southwest; (3) estimate, where possible, habitat-migrant associations, and (4) estimate variation in migrant height and direction of travel. This information will be valuable to USFWS and other landowners in dealing with regulatory issues of recent concern—e.g., the siting and permitting of communication towers and wind power turbines known to cause bird mortality—as well as for habitat protection and management.

**Studies of Mountain Plover Ecology:** Continuing studies of the Mountain Plover include (1) monitoring of breeding population trends at two traditional nesting sites in Colorado, (2) defining and quantifying agricultural impacts on Mountain Plover recruitment in Colorado, (3) evaluating the potential for using stable isotope technology to assess the status of the continental population, (4) determining the impact of habitat features on nest success from Wyoming to New Mexico, (5) evaluating the genetic structure of the continental population, (6) quantifying field-use patterns of the major wintering concentration in Imperial Valley, California, (7) screening contaminants exposure in Imperial Valley, California, and (8) providing technical assistance to the USFWS, BLM, and USFS on both wintering and breeding populations. This research lent instrumental support to the recent USFWS listing decision.

**Migration Stopover Ecology:** USGS scientists are studying migration stopover ecology of western land bird populations to identify geographic patterns of distribution and habitat use during migration in southwestern North America. This project synthesizes existing data from many studies and is an initial step in identifying regions important to “en route” western birds. USGS scientists are also examining shorebird population and habitat sampling problems in extensive, ephemeral wetland systems. Objectives of this study are to develop population estimates and methods for monitoring highly mobile and dispersed shorebirds in regions where dynamic ephemeral habitats predominate.

**Effects of Herbivory and Land Management Practices on Sagebrush Habitat:** The BLM oversees grazing, mining and resource development activities on roughly 107 million ha (264 million acres) in the western U.S., and much of this land is dominated by the sagebrush steppe vegetation type. Sagebrush ecosystems are currently being impacted by oil and gas exploration, grazing, road construction, and other types of developments. To help address research needs for the management of sagebrush habitats, the USGS and BLM are conducting investigations to study herbivory effects on sagebrush habitat and to evaluate treatments conducted in 1970 to determine

their long-term effects on sagebrush and sagebrush obligate species.

**Environmental Correlates of Greater Sage-Grouse Distribution and Population Trends:**

Patterns of distribution of greater sage-grouse populations and sagebrush habitats are well documented but the underlying causes for population trends or habitat changes are poorly understood. To address this critical information need, USGS scientists are working with state and university partners to correlate long-term trends in greater sage-grouse populations with habitat changes. We also are describing the effect of roads, power lines, and other infrastructures on greater sage-grouse populations, and testing the assumption that greater sage-grouse are an appropriate umbrella species for managing sagebrush habitats.

**Grassland Birds:** USGS scientists are studying the population demography of shortgrass prairie birds in intact, variegated, and fragmented landscapes. Ultimate goals of this research are to quantify population growth curves and to determine the status of selected breeding areas as population sources or sinks. Species-specific estimates of annual fecundity and post-fledging survival are being generated for Lark Buntings.

**White-Tailed Kite Population Ecology in California:** USGS scientists in the biology and geology disciplines have worked together to use innovative laboratory techniques to help assess white-tailed kite current and historic (past 100 years) population changes. Stable isotope analysis was used to assess whether kite prey base could be identified from feather and blood samples. If successful, this technique will be applied to historic museum specimens to determine whether severe population declines in the 1920s were related to changing prey base related to land-use patterns in California. We also applied conservation genetics to these historic museum specimens to determine whether a genetic bottleneck occurred during this decline, and whether current kite populations differ from kites present in California before the 1920s. The use of these innovative laboratory capabilities to reconstruct what has historically occurred within this species may help us better understand the causes of population declines in current avian populations.

**Wild Horse and Burro Research Program:** Wild horse populations increase at a constant high rate on western rangelands, creating a management challenge for the BLM. USGS scientists are working with the BLM and state agencies to generate the high-quality findings needed for informed, science-based management decisions. A recent modeling product from this research indicates that fertility control paired with other management techniques could reduce variable operating costs for the BLM Wild Horse and Burro Program by 21-31%. In addition, USGS scientists are refining a Wild Horse Identification and Management System (WHIMS) to help BLM and NPS researchers and managers identify individual wild horses in herd management areas with small, free-ranging populations.

**Preble's Meadow Jumping Mouse:** Results of a recent taxonomic study on subspecies of the meadow jumping mouse suggest that the Preble's meadow jumping mouse, currently listed as threatened under the Endangered Species Act, is not a valid subspecies. USGS scientists in Colorado are providing technical support to the USFWS during the five-year review of Preble's meadow jumping mouse as a threatened subspecies under the Endangered Species Act. Support includes (1) reviewing and summarizing available information pertaining to meadow jumping mice on the Northern Great Plains, including distribution, habitat affinities, relative abundance, and population trends of subspecies; and (2) conducting survey work to document distribution and occurrence of subspecies of meadow jumping mice in eastern Wyoming, southeastern Montana, northwestern Nebraska, and western South Dakota.

**Riparian Forest Management:** Riparian forests are widely recognized as important habitat for many native species, including migratory birds, small mammals, and ungulates. USGS scientists are researching the impacts of fire and ungulate browsing pressure on the maintenance and establishment of cottonwood and willow stands to develop sound management and restoration strategies in refuges and national parks.

**The Valles Caldera National Preserve:** The Valles Caldera Preservation Act designated approximately 89,000 acres of unique and spectacular lands in northern New Mexico as the Valles Caldera National Preserve, a unit of the National Forest System. USGS scientists have initiated or coordinated 27 different projects that will inform decisions on natural resource management at the Preserve and provide a foundation for future science. These studies include inventories of fish, wildlife, and plants, as well as broader studies of physical geology, preserve ecosystems, and paleoecology.

**North American Brant:** Effects of Changes in Habitat and Climate on Population Dynamics: USGS scientists and cooperators evaluated trend data for four arctic populations of brant during the non-breeding and breeding periods and examined changes in overall population size and shifts in winter distribution of brant with respect to variation in winter climatic conditions (North American Oscillation for Atlantic Brant and El Niño Southern Oscillation for Pacific Brant). Black and Western High Arctic Brant of the Pacific Flyway are the most dependent on eelgrass, and are undergoing a shift in winter distribution this is related to climate change and its associated effects on eelgrass dynamics. Variation in breeding propensity of Black Brant associated with winter location and climate strongly suggests that food abundance on the wintering grounds directly affects reproductive performance in these geese.

**Phylogeography of Coastal and Continental Gray Wolves in the Pacific Northwest:** USGS scientists and cooperators investigated the genetic structure of wolf populations in the Pacific Northwest to assess geographical structure and levels of variation throughout the region. A particular focus is the potential impact of episodic barriers and corridors related to the geological history of the region involving glaciers, changing sea levels, and geographical features that may promote isolation or contact between populations. Coastal wolf populations were distinctive from continental wolves and high levels of diversity were found within this isolated and relatively small geographical region. Significant genetic structure within southeast Alaska relative to other populations in the Pacific Northwest, and lack of significant correlation between genetic and geographical distances suggest that differentiation of southeast Alaska wolves may be caused by barriers to gene flow, rather than isolation by distance. Our genetic data are consistent with patterns of variation observed in other mammalian species inhabiting southeastern Alaska, and suggest that coastal wolves may represent a previously unrecognized and significant component of diversity in North American wolves.

**Effects of Maternal Characteristics and Climatic Variation on Birth Masses of Alaskan Caribou:** Understanding factors that influence birth mass of mammals provides insights to nutritional trade-offs made by females to optimize their reproduction, growth, and survival. USGS scientists evaluated variation in birth mass of caribou in central Alaska relative to maternal characteristics (age, body mass, cohort, and nutritional condition as influenced by winter severity) during 11 years with substantial variation in winter snowfall. Snowfall during gestation was the predominant factor explaining variation in birth masses, influencing birth mass inversely and through interactions with maternal age and lactation status. Maternal age effects were noted for

females  $\leq 5$  years old, declining in magnitude with each successive age class. Birth mass as a proportion of autumn maternal mass was inversely related to winter snowfall, even though there was no decrease in masses of adult females in late winter associated with severe winters. Caribou produce relatively small offspring but provide exceptional lactation support for those that survive. Conservative maternal investment before parturition may represent an optimal reproductive strategy given that caribou experience stochastic variation in winter severity during gestation, uncertainty of environmental conditions surrounding the birth season, and intense predation on neonates.

**Long-Distance Migration of Bar-Tailed Godwits:** Populations of the bar-tailed godwit embark on some of the longest migrations known among birds. USGS scientists are investigating the migration ecology of a race that breeds in western Alaska and spends the non-breeding season a hemisphere away in New Zealand and eastern Australia. There is now strong evidence that this population engages in a direct, non-stop flight of 11,000 km to wintering areas. Verification of these preliminary findings is being tested with new, lightweight satellite transmitters that have been implanted in a sample of breeding females on the Yukon-Kuskokwim Delta, Alaska during summer 2005.

**Winter Ecology of Threatened Spectacled Eiders: Environmental Characteristics and Population Change:** USGS scientists described characteristics of the wintering area used by spectacled eiders in the Bering Sea, Alaska, and evaluated these characteristics in relation to long-term population trends. Location of the wintering area were derived from satellite telemetry, ice conditions from remotely sensed data, weather conditions from archived data sets, and benthic communities from the literature. Based on analyses of two indices spanning 1957-2002 and 1988-2002, no single environmental parameter was indicated that explained the precipitous decline in nesting populations in western Alaska. The number of days with extreme sea ice in winter, extreme winds, and winds in spring explained the greatest variability in annual population indices. These analyses support the conclusion that annual population estimates on the breeding grounds can be negatively impacted by extended periods of dense sea-ice concentration and weather during the previous winter. Examination of population indices did not support the hypothesis that changes in benthic community on the wintering grounds have contributed to the decline or inhibited the recovery of the spectacled eider breeding population in western Alaska.

**Geographic Variation in Survival and Migratory Tendency among North American Common Mergansers:** Movement ecology and demographic parameter for the common merganser in North America are poorly known. USGS scientists used band-recovery data from five locations across North America spanning the years 1938-1998 to examine migratory patterns and estimate survival rates. The program MARK was used to study sources of variation in survival and reporting probability. Migratory tendency, defined as the average distance between banding and recovery locations, varied geographically. Model-averaged estimates of annual survival ranged from 0.21 in Michigan to 0.82 in Oklahoma. Heterogeneity in migration tendency and survival suggests that demographic patterns may vary across geographic scales, with implications for the population dynamics of this species.

**A Quantitative Approach to Identifying Predators from Nest Remains:** Nesting success of dusky Canada geese has declined greatly since a major earthquake affected southern Alaska in 1964. To identify nest predators, USGS scientists collected predation data at goose nests and photographs of predators at natural nests containing artificial eggs in 1997-2000. To document feeding behavior by nest predators, evidence from destroyed nests with known predators was compiled. A profile for each predator group was constructed and compared with evidence from 895

nests with unknown predators to predator profiles using mixture-model analysis. This analysis indicated that 72% of destroyed nests were depredated by bald eagles and 13% by brown bears, and also yielded the probability that each nest was correctly assigned to a predator group based on model fit. Model testing using simulations indicated that the proportion estimated for eagle predation was unbiased and the proportion for bear predation was slightly overestimated. This approach may have application whenever there are adequate data on nests destroyed by known predators and predators exhibit different feeding behavior at nests.

**Northern Fulmar Ecology:** Molecular markers and satellite telemetry are being used by USGS scientists to identify key areas where populations of northern fulmars congregate to feed and over-winter. Data from these studies are being used by the Office of Migratory Bird Management (USFWS) for addressing fishery bycatch issues.

**Alaska Seabird Ecology:** USGS scientists are using observation and experimental manipulation to study population dynamics and breeding ecology of colonial seabirds in artificial nesting habitats on Middleton Island. Current work focuses on feeding ecology of black-legged kittiwakes; site fidelity and over-winter survival of pelagic cormorants; and development of artificial habitats for studies of tufted puffins, rhinoceros auklets, and common murre. The analysis and explanation of seabird population trends in the Gulf of Alaska is especially timely now that ecologically related species such as harbor seals and Steller sea lions show indications of severe stress and steep declines.

**Polar Bear Ecology:** USGS scientists designed studies to explain the movements and activities of polar bears by investigating interactions between bears, their principal prey, ringed seals, and the sea ice that supports both of them are continuing. Current efforts are assessing changes in movements and distribution patterns of polar bears to provide information for addressing habitat management issues. Techniques for estimating population size and trend are continuing to be refined. Maternal denning habitat is being mapped and ways to detect bears in dens that may be buried deep under the arctic snow are being investigated to enhance our ability to protect mother bears and their newborns from human disturbances. Video techniques are being used to monitor bear activity outside undisturbed dens, providing a baseline for comparison to activity of bears denning in industrial areas.

**Predicting Bear Activity Patterns:** Relations between habitat characteristics and brown and black bear activity rates are being investigated by USGS scientists in Glacier Bay National Park. Results of this work will provide park managers with tools they can use to evaluate areas for potential bear activity and thereby reduce bear-human conflicts.

**Sea Otter Community Ecology:** A variety of approaches are being used by USGS biologists to develop an understanding of how sea otters affect their environment. Time-depth recorders are being used to study forage depth distributions and activity time budgets of sea otters in Alaska and California. Molecular genetic methods (primarily MtDNA) are being used to identify the degree of population structuring among north Pacific sea otter populations and to evaluate the effects of population reductions and translocations on sea otter genetic variability. These techniques are also being investigated to assess their utility in estimating dispersal distances for sea otters. The effects of varying sea otter densities on the structure and function of marine communities are being studied in Glacier Bay, Prince William Sound, and California, using a variety of observational and intertidal sampling protocols.

**Pacific Walrus Population Estimation:** Designs and techniques for remotely deploying satellite

transmitters on walrus are being developed and tested by USGS biologists. These transmitters will record the proportion of time walrus are in the water and therefore not available to be detected in aerial surveys over sea ice. Statistical design and analytical techniques are being developed to integrate information from the satellite transmitters with data from high altitude infrared imagery and low altitude digital photography in a range-wide aerial survey of the Pacific walrus population to be conducted by the USFWS in 2006 or 2007.

**Pacific Walrus Ecology:** Molecular genetic techniques are being used by USGS scientists to identify genetic structuring in the Pacific walrus population and to investigate the relatedness of individuals that are found in close proximity to one another on ice floes in the Bering Sea. Elemental isotope profiles in Pacific walrus teeth are being studied to investigate walrus group affiliation and the distribution of population segments.

**Finding the Needle in a Big Haystack:** Locating Surf Scoter Nests in the Northern Boreal Forest: In a pioneering study, a USGS-led team working with USFWS has tracked a surf scoter from its coastal wintering area in San Francisco Bay to pinpoint its nest, 2,000 miles away in the vast northern boreal forest of interior Canada. By marking individual surf scoters with satellite and radio transmitters while these sea ducks wintered in San Francisco Bay, the team has been able to document the birds' spring migration from wintering grounds to breeding grounds. Alarming declines in sea ducks have occurred over the past few decades, and degradation of breeding habitats (possibly linked to global climate change) and wintering habitats may be contributing to the declines. The San Francisco Bay area supports the largest wintering population of surf scoters in the Pacific Flyway; habitats are impaired by pollutants including mercury. Surf scoters in the Bay have elevated mercury levels, but little is known about the effects of this contaminant on their breeding success. While this is the first step in documenting breeding effects, the team is working with biologists from the Washington Department of Wildlife, Canadian Wildlife Service, Simon Fraser University, and the USGS with support from the North American Sea Duck Joint Venture to examine the breeding distribution of surf scoters from their major Pacific coast wintering areas extending from Mexico to British Columbia.

**Southern Sea Otter Recovery:** California sea otter numbers dipped to 2,735 in the 2005 spring survey, a 3.2 percent decrease in otters from the 2004 record high of 2,825. Despite the dip in this year's tally, the overall population trend, assessed by 3-year running averages, remains up. The latest 3-year running average of the 3 most recent spring counts is up 8 percent over the previous average, to almost 2,700 sea otters. Over the next year, USFWS will be closely examining sea otter range expansion into southern California; large numbers of sea otters were counted at the southern end of the range during 2005 spring survey.

**Xantus's Murrelets:** Xantus's murrelets were recently listed by the state of California as threatened, and predation at breeding colonies was identified within the listing decision as a significant obstacle to murrelet recovery. In a study by USGS and Channel Islands National Park (CINP), scientists investigated the impacts of nest predation on Xantus's murrelets by native deer mice on Santa Barbara Island, California, from 1983–2002. The researchers found that the mean nest occupancy rates by murrelets declined over the 20-year period, whereas the mean number of eggs hatching in a nest when it was occupied increased. Consequently, the total number of eggs hatching from this sub-colony for the past 20 years has remained unchanged.

**Use of Radio Transmitters on Breeding Alcids:** Externally attached transmitters may affect breeding alcids, because these birds fly long distances from their nests to feed and must pursue their

prey under water. In a radio telemetry study by USGS, Humboldt State University, and the University of California-Davis, scientists investigated effects of transmitters on the reproductive success of breeding Cassin's auklets in the California Channel Islands. They found that chicks raised by unmarked pairs had faster mass growth rates, faster wing growth rates, greater peak fledging masses, and higher fledging success than chicks raised by radio-marked parents. Fledging success was reduced more when the scientists radio-marked the male rather than the female parent. Transmitters did not appear to influence foraging ranges and at-sea distributions, however, since radio-marked Cassin's auklets foraged in similar areas compared to unmarked auklets that were surveyed concurrently by aircraft at sea.

**Tracking Ocean Wanderers:** Using satellite telemetry to track post-breeding seabirds, USGS scientists and collaborators are linking important migratory seabirds of the California Current to key marine habitats within the interconnected network of national marine sanctuaries - from southern California to the Pacific Northwest. The study is investigating the movements, habitat associations, and trans-Pacific migration of sooty shearwaters; the status, ecology, and aerial tracking surveys of ash storm-petrels captured in Channel Islands National Park, a non-migratory storm-petrel that resides year round within the California Current System; and satellite-telemetry of black-footed albatrosses captured at-sea in Cordell Bank National Marine Sanctuary, off central California, to better understand their post-breeding dispersal, distribution, and habitat-use. Shearwaters captured off central California were tracked to New Zealand and toward Chile. Preliminary genetic analyses indicate shearwaters mixing in flocks off California included individuals from colonies on both sides of the Pacific. Albatrosses captured within Cordell Bank NMS, north of San Francisco, ranged across the north Pacific, as far as Japan and crossed areas used extensively by long-line fisheries.

**California Central Valley Waterfowl Habitat:** Preliminary results of research on secondary production and biomass of aquatic invertebrates in post-harvest flooded fields in the Tulare Basin show that some Tulare Basin agricultural fields that are flooded after harvest provide important habitat during fall for northern pintails and other waterbirds in the Central Valley. The goal of this work is to provide information for managers to enhance wildlife benefits of these habitats. The research is part of a cooperative project by USGS and California State University-Fresno, with additional support from the Central Valley Joint Venture-USFWS and California Department of Fish and Game.

**Burrowing Owl Surveys:** Western burrowing owls are declining throughout much of their range, and are currently listed as endangered in Canada, threatened in Mexico, and considered species of special concern in the United States. Habitat destruction, pesticides, increased mammalian predation, and other human-related mortality have contributed to their decline. Accurate, habitat-specific productivity estimates are vital to understand the owl's population dynamics and, ultimately, to develop plans to retain viable populations. Establishing population surveys specific to burrowing owls is critical to determining status over its entire distribution and to facilitate conservation actions. Once a quantitative baseline has been established, future assessments of population trends will be possible. USGS scientists have completed population surveys to determine relative abundance and distribution of western burrowing owls at Marine Corps Air Ground Combat Center (MCACC) in Twentynine Palms and in the Clark County MSHCP area. Their habitat model will predict the presence of burrowing owls based on important habitat components and provide detailed recommendations for long-term burrowing owl management.

**Population Ecology of Mountain Lions (Cougars):** USGS scientists continue to study the

population ecology and movement of mountain lions across habitats fragmented by urban development in the Southcoast Ecoregion. In collaboration with the California Department of Fish and Game, USGS scientists strive to obtain baseline demographic information of mountain lions within the western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) and adjoining areas. Biologists are tracking both coarse and fine-scale movement patterns of mountain lions to learn how anthropogenic factors influence mountain lion movement, social interactions, and prey abundance and distribution. The project evaluates the presence of diseases in the mountain lion population; how social structure in a fragmented environment may affect transmission rates; and what the population level consequences may be.

**Cougars in the Wildland/Urban Interface:** USGS researchers are studying the potential for conflict between humans and cougars in Arizona. Research is focused on determining activities and movements of cougar when near humans, examining the sex and age composition of "backcountry" and "frontcountry" cougars, if such a distinction exists, determining the effects of highways, railroads, and urban areas on cougar movements, and developing models for predicting cougar activity.

**Sage Grouse Research:** USGS scientists are completing the final year of a 3- year study of greater sage-grouse in the Mono County area of California. Data collected include information on distribution, survival, and habitat use of greater sage-grouse throughout the Bi-State Region of California/Nevada. The USGS continues to work within the framework of the Local Working Groups to integrate sound science and adaptive management into the conservation of greater-sage grouse. In addition, genetic samples have been collected in the Mono area as part of the ongoing telemetry study and funds are currently being sought for analysis of these samples. New efforts in 2005 will include assisting the California Department of Fish and Game, the BLM and the US Forest Service in the development of a "California State Plan for the Conservation of Sage Grouse" and assisting in the monitoring efforts for West Nile Virus which was detected in the Mono area late in the summer of 2004.

**Research on the Desert Tortoise:** Research that aids in the recovery of the desert tortoise is a major emphasis of USGS scientists. The roles of drought, disease, raven predation, fire, habitat fragmentation through urban expansion, off-road vehicle pressures, and invasive species in the decline of the desert tortoise, are being investigated for the Mojave population of desert tortoises. Following their involvement in the completion of the Desert Tortoise Recovery Assessment in 2004, scientists are producing a desert tortoise translocation plan for the US Army. The plan is designed to minimize and mitigate the impacts of the imminent expansion of the National Training Center at Fort Irwin, CA. This plan will provide the scientific framework for the translocation of tortoises with an emphasis on desert tortoise conservation and research on translocation. New research will be conducted this spring to explore new techniques for finding tortoises during field surveys, and research to improve monitoring of this species will be continued. In addition, USGS scientists are conducting research on the effect of disease on desert tortoise populations. The goal of this research is to gain a better understanding of the distribution of Upper Respiratory Tract Disease in desert tortoises in Maricopa County, Arizona, and how this disease may relate to urbanization. Specific objectives are to 1) examine free-ranging wild tortoises and captive tortoises for clinical signs of URTD, 2) collect blood samples for laboratory analysis, 3) examine the relationship between occurrence of URTD and the extent of urban development.

**Centralized Biogeographic Information System in California:** USGS scientists are spearheading a new initiative, in collaboration with the California Department of Fish and Game, to

develop a centralized biogeographic information and observation system (BIOS) in California. BIOS integrates Geographic Information Systems (GIS) methods, relational database management, and internet mapping technology to create a statewide, integrated information management tool for biological observation data. The system will serve as a central, geographic and biologic data collection, management and dissemination warehouse, accessible by participating agencies and partners.

**Effects of Fire on the California Spotted Owl (*Strix occidentalis occidentalis*), and its Principal Prey, Northern Flying Squirrels (*Glaucomys sabrinus*):** The impact of natural fires, prescribed burning, and other management practices on wildlife (including the California spotted owl) at Yosemite is poorly understood. During 2005, USGS researchers (together with academic advisors from U.C. Davis) will determine the distribution of California spotted owls and their prey in Yosemite National Park as well as evaluate whether owls nest in recently burned areas and if they share the same success as those that nest in unburned areas. If there is a difference they will try to determine if that difference is based on differences in prey abundance or forest structure. They will also try to determine if owl diets differ between burned and unburned forest. A predictive model will be developed of nest occurrence based on fire history, vegetation characteristics, and indices of prey abundance.

**Research on Listed Species in California:** Studies of least Bell's vireos and southwestern willow flycatchers continue to document the demography and ecology of these protected species, particularly with respect to cowbird parasitism and the effects of invasive plant species on habitat quality. USGS scientists, in collaboration with the US Marine Corps and the California Department of Fish and Game, are focusing more intently on western burrowing owl population dynamics.

**Southwest Willow Flycatcher:** The USGS is studying endangered Southwest willow flycatchers over a large portion of their range in the Colorado River Basin in the Southwest, and in southern California to address effects of tamarisk invasion and other invasive species and effects of cowbird parasitism. Other research focuses on population ecology, genetics, migration, and winter ecology.

**Studies on the Ecology of Southwestern Riparian Birds:** In the Southwest, large rivers such as the Colorado, Green, and San Juan support extensive areas of native and exotic riparian habitats. Yet in many parts of these drainages, relatively little is known of bird abundance, distribution, and habitat affinities. The USGS scientists are documenting the abundance and distribution of bird species present in riparian areas of the Southwest, examining habitat use of species and communities, and developing and evaluating techniques for inventory and monitoring protocols.

**Research Support for Habitat Conservation Plans:** USGS research plays a key role in providing resource managers with the information they need to establish functional wildlife corridors and adequately designed reserves in a significant number of Habitat Conservation Planning efforts in California and Nevada. Research relating to urban-wildlife interface conflicts involving coyotes, mountain lions, desert bighorn sheep, and other important native species is a part of this effort.

**Piping Plover International Census:** Piping plovers are shorebirds endemic to North America and intense efforts have focused on recovery of the threatened and endangered species for almost 20 years. In 1991, the first International Piping Plover Census was conducted and focused on determining the species distribution, particularly during the breeding season. The second census was conducted in 1996 and focused on trying to delineate the winter distribution as well as determine breeding population estimates for viability modeling. The 1996 breeding census recorded

5,945 adults at 777 of 1,892 sites surveyed. Although numbers were down in much of the U.S. northern Great Plains compared to the 1996 census, an increase was detected on the Missouri River. This species-wide census allowed the authors to provide perspective on range-wide distribution and dispersal issues throughout the annual cycle. Results from complete species census efforts provide essential data for conservation planning and assessment and illustrate the utility of global censuses for all species of concern.

**Prairie Falcon Information Synthesis:** A USGS scientist recently co-authored a report for prairie falcons as part of a series of literature syntheses on North American grassland birds. The need for these reports was identified by the Prairie Pothole Joint Venture, a part of the North American Waterfowl Management Plan. This joint venture adopted the goal to stabilize or increase populations of declining grassland- and wetland-associated wildlife species in the Prairie Pothole Region of the central United States. These summaries provide managers with an overview of current knowledge of the habitat needs of grassland birds, and how management practices affect their habitats.

**Yellow-Billed Loons in Alaska:** The Yellow-billed Loon (*Gavia adamsii*) is the subject of a petition for listing under the Endangered Species Act due to its restricted range, small population size, specific habitat requirements, and perceived threats to its breeding and wintering habitat. Within the United States, this species breeds almost entirely within the National Petroleum Reserve-Alaska, nearly all of which has opened for oil development. Rigorous estimates of Yellow-billed Loon population size and trend are lacking but essential for informed conservation. The USGS and USFWS collaborators used two annual aerial waterfowl surveys to estimate population size and trend since 1986 on northern Alaskan breeding grounds. They found no evidence of a long-term trend in the Yellow-billed Loon population index on Alaskan breeding grounds since 1986, but there was high annual variation in the index, and the confidence interval around the trend estimate was large. The estimated population size, averaged over the past 12 years is 2,221 individuals in early June and 3,369 individuals in late June. Based on estimates from other studies of the proportion of loons nesting in a given year, it is likely that fewer than 1,000 nesting pairs inhabit northern Alaska in most years. This information was integrated with other findings in a November 2004 status assessment and conservation plan for the loon, prepared by the USGS for the USFWS.

**Conservation of Grizzly Bears:** USGS biologists are continuing long-term studies begun in 1977 under auspices of the Interagency Grizzly Bear Study Team. The current project emphasizes analysis, using data that were collected from radio-marked bears as well as from transects, survey routes, and random points, primarily from 1977-1992. Several recently completed elements focused on grizzly bear use of key foods in critical habitat complexes, including excavation of biscuitroots on convex rocky ridges, fishing for cutthroat trout spawning in streams tributary to Yellowstone Lake, consumption of carrion and kills on ungulate winter ranges, and excavation of whitebark pine seeds from caches made by red squirrels. The current focus is on an integrated analysis of relations among diet and gender, reproductive status, body size, condition, movements, and fecundity. Habitat suitability models are also being developed for grizzly bears.

**Yellow-Billed Cuckoo Status, Distribution and Habitat Use:** The status and distribution of Yellow-billed cuckoos are being studied by USGS researchers at critical locations in Arizona to develop habitat models for the species. Cuckoo locations are mapped in relation to vegetation classifications and orthorectified aerial photos and breeding status/success is being monitored. Very little is known about Yellow-billed Cuckoo ecology and the methodologies for determining actual numbers of individual cuckoos from survey data are still being developed. It has been found

that local populations of cuckoos can be highly variable, depending on food availability. The ongoing drought in Arizona has likely influenced the availability of their prey, primarily large insects. This, in turn, has likely influenced Yellow-billed Cuckoo habitat occupancy and site tenacity both within a breeding season and from year to year.

**Channel Islands Deer Mouse Population Ecology:** In this long-term study USGS researchers are investigating the nature and potential causes of population cycles in deer mouse populations on the Channel Islands of California. Populations on small islands without mammalian predators reach exceptionally high densities and fluctuate markedly in an apparent three- to four-year cycle; populations on larger islands with mammalian predators are much lower and do fluctuate markedly from year to year. The small island populations of deer mice differ from the well-established pattern for the species on the mainland, where populations occur in low to moderate numbers and are relatively stable from year to year. The pattern seen on the island is instead similar to that of cyclic microtines. The recent loss of the top predator - an endemic fox - on one of the larger islands provides an unprecedented opportunity to compare population dynamics in a small mammal population with and without generalist mammalian predators.

**Venomous Reptile Ecology in National Parks:** USGS scientists are conducting long-term research on the behavior, prey base, and ecology of gila monsters and three species of rattlesnakes at three National Monuments in central Arizona. Research begun in 1994 examined the effects and effectiveness of nuisance rattlesnake relocation at Montezuma Castle National Monument and examined the movement patterns of rattlesnakes at Tuzigoot National Monument. Current telemetry research includes Tonto National Monuments and focuses on proximate causes of nuisance rattlesnake movements and behavior in human-modified habitats. This work has been enthusiastically supported by the parks, as it provides interpretive opportunities for visitors and experimentally addresses the complex issue of feeding wildlife in staff housing areas.

**Narrow-Headed Garter Snake Status and Ecology in Oak Creek, Arizona:** USGS scientists are conducting pivotal telemetry and monitoring research on narrow-headed garter snakes (*Thamnophis rufipunctatus*) in Oak Creek, Arizona. This species is of special concern across its North American range due to an apparently declining status. This research is significant because, in addition to being the first telemetry study of the species, it involves close collaboration with the US Forest Service and Arizona Game and Fish Department, and has been enthusiastically supported by several private landowners. The USFWS will use results from this research to help determine if the species is in need of additional federal protection.

**Arizona Black Rattlesnake Movements and Ecology:** USGS scientists are conducting the first telemetry and monitoring research for Arizona Black rattlesnakes (*Crotalus cerberus*) in Arizona. This species has not been previously studied using telemetry, and its subspecific status, ecological requirements, and overall biology are poorly known. This research includes US Forest Service, Northern Arizona University, and National Park Service partners.

**Methods for Monitoring the Status and Trends of Seabirds Breeding in the Hawaiian and Pacific Islands:** Seabirds face numerous anthropogenic threats such as oil spills, interactions with commercial fisheries, predation by introduced species, habitat loss, human disturbance, and global warming. Determining the status of Hawaii's seabird populations and documenting population trends is difficult because seabirds spend most of their lives at sea and most breed on isolated islands. This USGS project will include: 1) a comprehensive strategy for determining status and trends; 2) identification and rationale for population parameters to be monitored; 3) detailed,

standardized protocols for data collection, and 4) a review of existing data and analysis for target seabird species that breed in the Hawaiian Islands will be produced for the office of Migratory Birds and the Hawaii and Pacific Islands National Wildlife Refuge Complex.

**Biocomplexity of Introduced Avian Diseases in Hawaii:** USGS scientists have been investigating the biocomplexity of introduced avian malaria and pox virus in collaboration with investigators from the University of Hawaii, Princeton University and the Smithsonian Institution. USGS research is integrating investigations of demographic studies of exotic and endemic forest birds, mosquito vectors, and pox and malarial parasites using study plots that span a range of climate, hydrology, and vegetation patterns. Complementary laboratory studies focus on genetic variation of hosts, vectors and parasites and epidemiological factors such as host susceptibility and resistance, parasite virulence and vector competency. Some key findings include discovery of re-emergent low elevation Hawaii Amakihi populations in the Puna District of Hawaii Island, experimental studies that document evolving disease resistance in these birds, and development of models that can be used to predict annual variations in mosquito populations and disease transmission.

**Risk Assessment for Selected Avian Diseases in Hawaiian and Pacific Parks:** USGS scientists are investigating the distribution of introduced mosquito vectors, avian malaria and avian pox virus at Haleakalā National Park (HALE), Kalaupapa National Historic Park (KALA) and National Park of American Samoa (NPSA). All three parks contain some of the most pristine native ecosystems left on their respective islands, but the current status and long-term sustainability of their native forest bird communities differ dramatically. Key findings have been the relatively low prevalence of avian diseases and disease vectors at the Kipahulu Valley Unit of HALE, high prevalence and abundance of avian disease at KALA, and discovery of a previously unrecognized indigenous blood parasite fauna at NSPA. The latter is particularly interesting because it highlights the isolation of the Hawaiian Islands and the potential impacts that invasive diseases like West Nile Virus may have on endemic forest birds in this archipelago.

**Foraging Ecology, Population Dynamics, and Translocation of the Endangered Laysan Duck (*Anas laysanensis*):** The Laysan duck (*Anas laysanensis*) has the most restricted range of any duck species and is especially vulnerable to extinction because of its single and small population (400-600 Laysan ducks). Despite its previously archipelago wide distribution, today the Laysan duck shows strong tenacity to Laysan Island in the Northwestern Hawaiian Islands National Wildlife Refuge Complex (NWR), and successful dispersal from the island is unknown. Working with Refuge managers, USGS scientists have been providing research on the population dynamics, foraging behavior, seasonal prey availability, reproductive success, and habitat use on Laysan. Scientific results have been used to make recommendation on recovery strategies, and ecosystem restoration to benefit Laysan ducks. In October 2004, USGS and USFWS conducted an experimental translocation of 20 wild fledged juveniles from Laysan to Midway Atoll National Wildlife Refuge. Survival was 100% and breeding was documented within the first year post-release. The 2005 experimental translocation is dependent on securing a transport boat and funding for staff support. Post release monitoring is ongoing to determine survival, habitat use, foraging behavior, and reproductive effort. In addition to helping the USFWS create an insurance population for the species, USGS is testing techniques to establish viable populations and evaluate probability of population persistence. Scientists are interested to compare habitat use, demographic parameters and ecological release between Laysan and Midway Islands.

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## **FISHERIES**

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**Genetics Research on Pacific Salmonid Populations:** A variety of molecular techniques are being developed and used by USGS scientists to characterize Pacific salmon populations in Alaska. These studies are contributing to synthesis of information on the evolutionary history of Pacific salmon, colonization patterns across multiple habitats, species interactions and genetic introgression, comparisons of different life history strategies in relation to anthropogenic activity and habitat quality, and genetic population structure for fish found throughout the genus' range.

**Salmon and Whitefish Ecology:** Long term monitoring of salmon population dynamics by USGS scientists in Lake Clark National Park and Preserve is being supplemented with initiation of research to determine basic life history characteristics of whitefish populations in the region. Molecular genetic methods are also being used to identify and examine the structure of whitefish populations throughout Alaska. Whitefish are an important subsistence species in this region.

**Salmonid Life Histories:** Daily growth increments and analyses of strontium/calcium ratios in otoliths are being used to describe the migration history relative to ages of juvenile chum in Kuskokwim Bay. The work of USGS scientists is providing important information about the critical period in salmonid life history when they make the transition from freshwater to marine environments. The use of multi-elemental analysis of otoliths is also being investigated for application to the study of homing and straying of Norton Sound chum and coho salmon.

**Body Condition and Feeding Ecology of Chum Salmon:** Because the early life history of salmon populations in western Alaska is poorly understood, it is difficult to develop or test hypotheses concerning population regulation and the role of environmental variation or change. Body condition of chum salmon fry in the Kuskokwim River is being assessed by USGS scientists with length/weight analysis, caloric content, lipid class, and fatty acid composition in relation to outmigration distance. This work will provide basic information on how salmon fry compensate energetically to survive downstream migrations.

**Testing Archival Tag Technology:** New technologies involving electronic archival tags for fish are in development by USGS scientists with applications for investigations of in situ fish/habitat relationships previously unavailable with old technologies. The use of archival data storage tags is currently being evaluated for use on repeat spawning steelhead in the Ninilchik River to monitor ocean habitat conditions and movement between spawning events.

**Klamath River Systems Impacts Assessment:** USGS scientists are collecting data to estimate biological productivity of young-of-the-year Chinook salmon in the Klamath River and calibrate the production model SALMOD. Specific objectives include 1) measure and mark Chinook carcasses to estimate of total numbers via Petersen and Schnabel capture-mark-recapture techniques; and 2) measure abundance and size of fall-run Chinook at three fixed locations in the Klamath River above the Scott River confluence.

**Lower Colorado River: Endangered Fish Recovery Studies:** Ongoing studies are documenting spawning requirements for razorback suckers and bonytail, and evaluating the use of predator-free off-channel rearing ponds to allow the fish to grow to > 30 cm, which greatly reduces the losses to non-native fish predators.

**Colorado River:** USGS is engaged in cooperative research efforts with Arizona Game and Fish Department on Humpback Chub in the Colorado River in Grand Canyon National Park. Other species such as flannelmouth sucker and bluehead sucker are also being monitored and studied. USGS is also providing science support to the Glen Canyon Dam Adaptive Management Program. Recently we have worked with stakeholders to develop a proposed science program to support the Multi-Species Conservation Program in the Lower Colorado River.

**Mercury Concentrations in Fish in the St. Croix River:** USGS scientists in collaboration with the National Park Service (NPS) are leading an effort to determine the distribution of fish-tissue mercury concentrations in selected reaches of the St. Croix River. The St. Croix is a National Scenic Riverway managed by the NPS that forms the northern half of the border between Minnesota and Wisconsin. Research will provide information on variations in fish-tissue mercury concentrations and their relationships to stream-water methyl and total mercury concentrations, total mercury concentrations in stream sediments, and characteristics of land use within the watershed.

**Documentation of Water-Quality and Streamflow Conditions in White Sands Pupfish**

**Habitat:** The White Sands pupfish (*Cyprinodon tularosa*) is listed as threatened by the State of New Mexico and as a federal species of concern. The fish is vulnerable to competition from non-native fish and degradation of aquatic habitats. USGS scientists, in cooperation with White Sands Missile Range have compiled information on the water quality and streamflow conditions of pupfish habitat areas on the missile range. Documentation of water-quality and streamflow conditions in pupfish habitat areas will help to evaluate current and future management activities with regard to habitat conservation.

**Real-Time Monitoring of Water Temperature in the Mountain Fork River:** The USGS operates three continuous water-temperature gages with real-time reporting along the Mountain Fork River that enable the Oklahoma Department of Wildlife Conservation to monitor temperature changes during reservoir releases for the preservation of trout population and habitat. The real-time data provide information necessary to adjust and time reservoir releases and prevent possible fish kills.

**Mercury in Fish Tissue in the North Canadian River:** A recent synoptic sample collection of fish tissue was analyzed for mercury concentrations as part of the NAWQA Program at two locations along the Canadian River (near Calumet and at Britton Rd at Oklahoma City). These initial samples indicated elevated levels of mercury in catfish and sunfish fillets at the Calumet site. Additional data collection is anticipated to occur to further the initial study.

**Selenium and Mercury in Fish:** USGS scientists, in cooperation with the Colorado River Water Conservation District, are conducting a reconnaissance investigation of selenium and mercury in fish in Wolford Mountain Reservoir in Colorado. Lower-elevation areas of the watershed for the reservoir are underlain by marine shale, a possible source of selenium. Coal-fired power plants, possible sources of mercury, are located upwind of the reservoir to the northwest. Prior trace-element contaminant investigations have not been conducted at the 10-year old reservoir.

**Water Quality Assessment of Growout Ponds Used for Colorado River Endangered Fish (Razorback Sucker) Propagation:** The lower Gunnison River and the Colorado River are designated critical habitat for two endangered fish species: the Colorado pikeminnow (*Ptychocheilus lucius*) and the razorback sucker (*Xyrauchen texanus*). Because of inadequate recruitment for these endangered fish species, the Upper Colorado River Basin Recovery Program

decided that captive propagation and stocking was necessary to restore and augment populations of the endangered fish. It is highly probable that some of the grow-out ponds used for propagation of razorback suckers have elevated selenium concentrations because they receive irrigation tail-water and groundwater produced from deep percolation of irrigation water. Recovery goals for the razorback sucker and Colorado pikeminnow acknowledge that selenium is a water-quality factor that may inhibit recovery by adversely affecting reproduction and recruitment. The USGS is responsible for the water-quality monitoring component of this study with the following objectives: 1) Assess water-quality (focusing on selenium) and food supply availability and chemistry in 16 grow-out ponds used propagate juvenile endangered razorback suckers, and better define factors associated with water quality which may limit growth, condition, and survival of razorback suckers in both grow-out ponds and eventually after stocking in the Colorado and Gunnison rivers; 2) Determine selenium concentrations in water, sediment, food-chain items, and in razorback suckers.

**Effects of Road Removal on Tailed Frogs:** USGS is studying the short-term impacts of road decommissioning on the biomass and condition of larval tailed frogs in Redwood National and State Parks. Tailed frogs, a species of special concern, appear to be sensitive to disturbance and can serve as indicators of stream conditions for several other vertebrate species in the Pacific Northwest. Scientists are sampling for tailed frogs in three tributary groups – sites with low disturbance, moderate disturbance, and high disturbance. Preliminary results (based on 2004 sampling) showed a significantly higher biomass of tailed frogs in low-disturbance and moderate-disturbance tributaries compared to high-disturbance sites. Additionally, larval tailed frogs were much heavier in low disturbance sites compared to either moderate-disturbance or high-disturbance sites. The preliminary results of this study provide evidence to suggest that road decommissioning may have a negative effect on tailed frog biomass and condition, at least over the short-term.

**Suspended Organic Sediment Affects Turbidity and Fish Feeding Behavior:** USGS scientists are investigating the complex relationship between turbidity in coastal streams and fish feeding behavior. Turbidity in streams and estuaries is produced by particles, both organic and inorganic suspended in the water column. In coastal streams water clarity is becoming increasingly impaired by such land uses as grazing, mining, timber harvest, and road construction. During high stream flows triggered by storms, particles such as sand and silt become suspended. As the flow declines, the inorganic particles settle out and the lighter organic particles remain suspended causing low to moderate turbidity and reduced light penetration. This decrease in light may lead to decrease in algal production and a subsequent loss of invertebrates that depend on them. At the same time, suspended organic particles can benefit filter feeding invertebrates. Preliminary results show that invertebrate samples from the stomachs of juvenile coho and steelhead decline with increasing turbidity. Also observed was a decline in the rate of prey capture by juvenile salmonids with increasing turbidity.

**Information Needed for Enhancement of Independence Lake Strain Lahontan Cutthroat**

**Trout:** The Independence Lake Lahontan cutthroat trout is one of two extant lacustrine Lahontan cutthroat trout populations. Historically, spawning migrations of 2,000 to 3,000 cutthroat migrated from the lake into Independence Creek, but in the last 50 years run sizes have ranged from about 50 to 150 fish. The decline in spawners has been attributed to the introduction of non-native kokanee and brook trout. Studies are being conducted to determine the mechanism by which non-natives replace cutthroat, and to generation information needed to control or eliminate non-native salmonids from the Independence Lake system.

**Cui-ui Population Dynamics Model:** USGS biologists have developed a cui-ui population dynamics model sensitive to spawning frequency and are preparing support papers on cui-ui life history traits and survival. A recently completed paper demonstrates tremendous plasticity in cui-ui life history traits. The cui-ui population has increased over 10 fold and this was followed by a significant increase in means age at maturity, reduction in growth rate and survival. Size at maturity is invariant for both males and females. Incorporating this information on density dependent life history traits will improve the accuracy of the model.

**Diel Spawning Behavior of Chum Salmon:** Flows from Bonneville Dam on the Columbia River are managed during the chum salmon spawning season under the assumption that fish do not spawn at night. The USGS examined the prevalence of nighttime spawning and associated behaviors of wild chum salmon in the Columbia River. Findings revealed that chum salmon are capable of spawning at night, and no differences in spawning behaviors were observed between day and night. Once chum salmon begin nest construction, visual cues are apparently not required for courtship, nest defense, and spawning. These findings show the assumption that fish do not spawn at night is false, and releasing high flows from hydroelectric projects at night should be reevaluated.

**Development of Instream PIT-Tag Detector:** Scientists from the USGS have developed a detector system for stream fish implanted with Passive Integrated Transponder (PIT) tags (12 mm, full duplex type). With extensive collaboration with scientists of NOAA Fisheries, our objectives to have continuous monitoring of fish movement in a small stream throughout the year and to be able to assess detection efficiency have largely been achieved. The system has proven to withstand challenging flow, temperature, and debris conditions. Two of these systems are currently deployed in the State of Washington: one in the White Salmon River watershed and the other in the Methow River watershed. Success has relied on the improvement of transceiver technology, on quality of electrical power to run the system, design of antennas, and our ability to adequately anchor the antenna in the stream. Detection of tagged fish passing this stationary PIT-tag detector is providing valuable information on how selected fish species behave and how they use a stream network.

**Development of Humpback Chub Bioenergetics Model:** Scientists from the USGS recently developed and applied a bioenergetics model for humpback chub *Gila cypha* in the Colorado River. Humpback chub are federally listed as an endangered species and actions to recover the species are being implemented throughout the lower Colorado River. One action being contemplated is the installation of a temperature control device (TCD) on Glen Canyon Dam, immediately above Grand Canyon National Park. The bioenergetics model was developed and used to help scientists and managers evaluate how altered temperatures from a TCD might affect humpback chub growth and survival. In the initial publication, the model was parameterized and applied to show that proposed temperature changes from the TCD may not improve chub growth rate if food sources do not increase proportionally. Researchers are also using the model to evaluate predator-prey interactions between humpback chub and rainbow trout, which feeds on juvenile chub in the lower Colorado River, especially below Glen Canyon Dam.

**Annual Survival of Adult Lost River Suckers and Shortnose Suckers in Upper Klamath Lake:** USGS researchers examined variation and trends in annual survival of two endangered sucker species inhabiting Upper Klamath Lake, Oregon to provide insight into the magnitude of summer mortality events caused by crashes of massive summertime algal blooms in the lake. Analysis of capture-recapture data collected beginning in 1995 indicates dramatic annual variation in adult sucker survival with annual survival rates substantially lower during years experiencing a summer mortality event. A resistance board fish weir and remote underwater passive integrated transponder

tag readers were incorporated into the capture-recapture study design during the 2005 spawning season to improve our ability to re-sight tagged fish. These efforts will improve survival estimate precision and allow for the estimation and modeling of other population parameters such as recruitment, breeding probability, and the finite rate of population change.

**Lost River and Shortnose Sucker Spawning Migrations in the Upper Klamath Basin:** The Sprague River dam has been identified as a potential impediment to spawning migrations of endangered Lost River and shortnose suckers. Proposed remedies range from improved fish ladders to dam removal. To evaluate the distribution and extent of spawning areas used by suckers above the Sprague River dam prior to any action to improve fish passage, USGS researchers tracked the movements of radio tagged Lost River and shortnose suckers as they migrated from Upper Klamath Lake, Oregon and entered tributaries to spawn. Data collected to date indicate Lost River and shortnose suckers appeared to only spawn in the mainstem Sprague River. In upriver areas most spawning was limited to discrete sites while spawning in the lower river occurred throughout the river. Suckers that entered the Sprague River in early spring traveled and spawned furthest upriver (to approximately river kilometer 125) while those that entered later in spring principally spawned in the lower 15 river kilometers of the river. Results also indicate certain river reaches are important to adult suckers as upstream and downstream migration corridors and as holding areas. Upstream movement rates of adult suckers appear to be related to water temperature with the migration prolonged at colder temperatures. Adult emigration from the tributary back to Upper Klamath Lake was typically rapid. Data from a companion study to monitor larval sucker production in the Sprague River verified areas of spawning and each area's relative contribution to overall larval sucker production of the Sprague River.

**Life History and Ecology of the Santa Ana Sucker:** The USGS sampled Santa Ana suckers in the San Gabriel and Santa Ana rivers of southern California to gain insights on the life history and ecology of this federally listed threatened species. Findings revealed that suckers were more abundant in relatively pristine reaches of the San Gabriel River than in highly altered reaches of the Santa Ana River. Evidence of natural reproduction (presence of fry) was observed in both rivers, with spawning possibly occurring earlier in the year in warmer waters of the Santa Ana River. Suckers were in higher body condition but grew slower in the San Gabriel River than in the Santa Ana River.

**Environmental Limiting Factors of Desert Pupfish:** USGS scientists assessed the relation between abundance of desert pupfish (a federally listed endangered species) and selected biological and physicochemical variables in natural and manmade habitats within the Salton Sea Basin. Pupfish were most abundant in habitats where water quality extremes-high pH and salinity, and low dissolved oxygen-seemingly limited the occurrence of nonnative fishes such as porthole livebearers, tilapias, longjaw mudsuckers, and mollies. Pupfish were positively associated with cover and with habitats containing fine-grained sediments. Longjaw mudsuckers were found to prey on pupfish.

**Habitat Requirements of the California Freshwater Shrimp:** The USGS investigated the habitat requirements of the California freshwater shrimp, a federally listed threatened species. Shrimp were most numerous in habitats characterized by overhanging streambank vegetation, submerged fine root masses, sandy substrate, and low current velocity where threespine stickleback and California roach were also numerous. Analysis of fish gut contents indicated that prickly sculpin and riffle sculpin preyed on shrimp.

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## INVASIVE SPECIES

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**Introduced Vectors of Avian Disease in Hawaii:** As part of an ongoing collaborative study with the University of Hawaii, Smithsonian Institute and Princeton University, USGS scientists are examining the role of mosquitoes, *Culex quinquefasciatus*, in the Biocomplexity of Introduced Avian Disease in Hawaii. This landscape to molecular scale research is in its fifth and final year of NSF funding. Modeling efforts have revealed the significance of temperature and precipitation in driving annual populations of vector mosquitoes while field results indicate an association of feral pigs with available larval mosquito habitat. Our researchers have also detected a newly introduced mosquito, *Aedes japonicus*, in native bird habitat. We have found that in laboratory susceptibility studies *Aedes japonicus* does not support *Plasmodium relictum* development. USGS scientists are also looking at the interactions between introduced mosquitoes and native and non-native birds to better understand the dynamics of transmission. Non-native birds are significantly less likely to allow mosquitoes to blood feed than native birds.

**Epizootiology and Control of Avian Diseases in Endangered Forest Bird Habitat in South Kona, Hawaii:** USGS scientists are completing investigations of introduced mosquito vectors and the diseases they carry at the Kona Forest Unit of Hakalau Forest National Wildlife Refuge. Baseline data on prevalence of pox and malaria in forest bird populations, seasonal and elevational distribution of mosquito vectors, and characteristics and distribution of mosquito breeding sites were used to design and test an experimental vector control program in endangered forest bird habitat. Close association between feral pig damage to the forest understory and creation of egg-laying sites for mosquitoes was apparent. Results indicate that physical drainage of egg-laying sites is feasible, and that mosquito reduction is possible if the treatments can be repeated regularly until management units are fenced and feral ungulates are removed.

**Developing New Strategies to Manage Mouflon in Hawaii:** A USGS study in conjunction with the National Park Service is monitoring the population status of a non-native wild sheep, the European mouflon, which was introduced in 1968 to what is now part of Hawaii Volcanoes National Park. Mouflon have been introduced to both continental areas and oceanic islands worldwide. Rapid population growth has resulted in damage to thin soils through hoof action in continental areas, but most notably, the destruction of sensitive endemic plants through herbivory on islands. Several species of threatened and endangered plants are vulnerable to mouflon in Hawaii. This study will also examine the effectiveness of different management strategies for mouflon in Hawaii.

**Efficacy of Feral Pig Removals at Hakalau Forest National Wildlife Refuge:** A USGS study in conjunction with the USFWS is examining population dynamics and effectiveness of different methods during feral pig removal at Hakalau National Wildlife Refuge in Hawaii. Feral pigs have major impacts on native plant communities in insular ecosystems through rooting and herbivory, but may also play an important role in the transmission of avian malaria to the native birds of Hawaii by creating wallows in which mosquitoes breed. The control of feral pigs is difficult, however, because they are cryptic, live in dense forest environments, and have high reproductive potential. This study is developing methods to determine the density of feral pigs through activity index surveys, and determining the effort needed to remove pigs from protected areas.

**Reducing Feral Cat Threats to Native Wildlife in Hawaii:** USGS scientists are working to develop methods to reduce the depredation of native Hawaiian birds by feral cats. The objectives of

this research are: 1) improve techniques for attracting cats to traps with lures that require infrequent refreshing or maintenance; 2) develop ‘smart trap’ technology that notifies managers when traps contain animals; 3) develop adaptive management strategies for controlling feral cat populations in a variety of habitats and parks in the Pacific; 4) document the impacts of feral cats on native wildlife; and 5) prepare information on feral cat problems that help inform decision-makers and the public of the value of cat control programs in national parks.

**Refine Strategies to Prevent Spread of the Invasive Argentine Ant to Protect Pollinators and Other Endemic Insects of Haleakalā National Park (HALE):** The highly invasive Argentine ant (*Linepithema humile*) was first recorded in the Hawaiian Islands in 1940 and at HALE in 1968. Hawaii lacks native ants, and research at HALE has showed that the ants have dramatically negative impacts on endemic arthropods, including the pollinators of native plants such as the silversword. The Argentine ant is only one of many invasive ant species in Hawaii, but as yet no other aggressive ant species invades high-elevation habitats. DOI has been monitoring and mapping of the ant populations at Haleakalā since 1980. Since 1995, USGS scientists have mapped the distribution of the ant every year. Adaptive management by NPS resource managers and USGS scientists has taken the form of “border treatment,” a holding action using ant baits to prevent the spread of the highly destructive ant. Efficacy and non-target impacts are quantified annually and are used to plan subsequent applications. “Border treatment” with Maxforce, a protein bait with the active ingredient hydromethylnon, is an effective holding action (though still needing refinements) to prevent unrestrained spread of the Argentine ant into terrain never previously subjected to ant predation on upper Haleakalā volcano. However, better methods will be needed in the long run to prevent eventual annihilation of the endemic insect fauna of upper Haleakalā (consisting of ca. locally 80 endemic species).

**Planning and Surveillance for Prevention of Red Imported Fire Ant Establishment in Hawaii:** The Red Imported Fire Ant (RIFA, *Solenopsis invicta*) has spread across southern U.S. and was first detected in 1998 in California (triggering a \$40 million, 5-year response), although it is estimated that RIFA were present for at least five years before detection. RIFA was first detected in early 2001 in Australia (triggering an A\$175 million, 6-year response), but were estimated to have been present and undetected for ten years. New Zealand was able to eradicate RIFA from sites in Auckland and Napier – zealous surveillance for RIFA is an important tool in preventing its establishment. USGS scientists are working with Hawaii Department of Agriculture toward building an effective system for preventing invasion of Hawaii and Pacific islands by the Red Imported Fire Ant and Little Fire Ant (LFA; *Wasmannia auropunctata*). Initial steps involve establishing and testing practical protocols for detection of RIFA and LFA in the State of Hawaii in cooperation with federal, state, and local agencies.

**Early Warning for High-Risk Incipient Invasive Species in Hawaii and Other Pacific Islands:** Land managers on the 1860 km<sup>2</sup> Hawaiian island of Maui realize that long-term protection of their resources will depend more than anything else on the success of keeping new invasive alien plant and animal species currently not yet present on the island from becoming established on an island-wide level and dealing with those already established before they reach their lands. USGS scientists are evaluating and implementing methods for early detection and reporting of information on the distribution, biology, and potential impacts of incipient invasive plants, the Red Imported Fire Ant, Little Fire Ant, vespid wasps, and tree-attacking beetles on the island of Maui. They are also obtaining experience in assessing opportunities for eradication or containment. They routinely report such opportunities to an interagency group, the Maui Invasive Species Committee (MISC), an institution with 30 employees that has made serious headway over the past six years through

surveying, treating, containing, and eradicating some of the most serious invasive species that threaten ecosystems of Maui, including Haleakala National Park and other natural areas. MISC's efforts are being emulated by four other island invasive species committees in Hawaii and other islands of the Pacific (e.g., American Samoa, Palau). USGS scientists are now refining methodology suitable for exporting the Maui early detection model.

**Phenology and Dispersal of Invasive Weeds in Kipahulu Valley, Haleakalā National Park, Maui:** Rain forests of northeastern Haleakalā volcano are among the most intact and richest biologically in Hawaii. Within Kipahulu Valley of Haleakalā National Park, feral pigs (*Sus scrofa*) have been excluded for more than 15 years, an intact ground cover has been regained, and native plant species are thriving. Despite this apparently robust "ecosystem health", a few of the most aggressive alien plant species continue to pose a highly significant threat to the long-term conservation of this critically important area, which provides habitat for four federally endangered bird species, over a dozen federally endangered plant species, and numerous very rare endemic invertebrate species. The primary invasive and damaging alien plant species include Koster's curse (*Clidemia hirta*), strawberry guava (*Psidium cattleianum*), and kahili ginger (*Hedychium gardnerianum*). USGS research has provided understanding of the biology of the weeds and of the mechanisms of invasion in the rain forest ecosystem. The project has suggested that mechanical and chemical control methods will ultimately prove inadequate for addressing these species. Biological control appears to be the only effective long-term solution for relatively intractable weed species in Hawaii's rain forest, such as clidemia, kahili ginger, and strawberry guava.

**Evaluation of Potential Agents for Biological Control of Miconia and Other Alien Plants Highly Invasive in Hawaiian Ecosystems:** An ornamental tree (*Miconia calvescens*), introduced to Hawaii in the 1960s, and is beyond conventional control techniques. Mechanical and chemical controls are unsustainable in remote inaccessible areas and because the enormous extent of the infestation (especially on the Big Island), rapid regeneration of seedlings, and the unacceptably large annual program expense makes this approach unfeasible. All land managers in the state now accept the necessity for biological control. One biological control agent, the fungal pathogen (*Colletotrichum gloeosporioides* f. sp. *miconiae*), has been released, but its effect is minimal to date. Current USGS research focuses on identifying potential agents within the native range of (*Miconiacalvescens* spp.) (Brazil and Costa Rica), conducting preliminary analyses of their host specificity, and developing techniques for propagating promising candidates.

**Prevent Palmyra Pisonia Forest Death:** Palmyra is the only wet equatorial atoll within the United States' jurisdiction, and until very recently had one of the best remaining examples of (*Pisonia grandis*) forest found in the Pacific region. Currently, (*Pisonia grandis*) forests of Palmyra are being attacked by the ant-tended scale insect (*Pulvinaria urbicola*) (a Caribbean species) in sites throughout their wide range, from the Seychelles, east to the Coral Sea Islets of Australia's Great Barrier Reef, to Rose Atoll in American Samoa, and to Palmyra. Between 2001 and 2002, field researchers reported a 50% reduction in (*Pisonia* spp.) forest canopy density at Palmyra, attributed to a severe infestation of an invasive ant-tended scale insect, now known to be (*Pulvinaria urbicola*). The alien scale insects pose a direct threat to survival of (*Pisonia* spp.) trees, and thus to a major forest type and seabird habitat of Palmyra NWR. Very high levels of scale insects and ants were noted through 2004, and large areas of (*Pisonia* spp.) forest had been decimated. USGS scientists are working with USFWS Refuge managers and university researchers to develop and implement (if possible) an integrated pest management strategy to allow survival of the (*Pisonia* spp.) forest, while avoiding unacceptable deleterious effects on non-target organisms. Preparatory steps include analysis of the ecological costs vs. benefits of introduction of the coccinellid scale

predator (*Cryptolaemus montrouzieri*) to the Palmyra (*Pisonia* spp.) forest, and analysis of the ecological costs vs. benefits of treatment (with Amdro, active ingredient hydramethylnon) of the ants (*Pheidole megacephala*, *Tetramorium bicarinatum*, *Paratrechina bourbonica*, and *P. vaga*), and prospects for using food lures to divert native crabs from the baits. As of mid-2005, all environmental compliance documents have been prepared, and USFWS is evaluating whether they can marshal the resources needed to proceed.

**Ecological Forecasting of Invasive Species:** NASA and USGS scientists have combined expertise to couple software engineering and satellite data to develop the Invasive Species Forecasting System (ISFS), a new Internet-based tool to combat troublesome invasive plant species across the West. The ISFS is a web-based tool that uses NASA satellite data to analyze past and present distributions of non-native organisms and predict their future distribution and abundance, based on ecological factors. Land managers and others can use the ISFS to generate color-coded maps that will help them limit the spread of existing invasive plants and prevent new invasions. The model has successfully been tested on Tamarisk, an invasive riparian species.

**Riparian Invasive Species - Ecology, Impacts, Control, and Restoration:** Beginning in the early part of the 20th century, shrub species of the non-native tamarisk (or saltcedar) and Russian-olive were introduced to the United States for use as ornamental plants and erosion control plantings. The great abundance of tamarisk along western rivers particularly in the southwest, has led resource managers to seek to control it for various reasons, with special interest in water salvage. As part of a recently initiated research effort, USGS scientists are mapping the current distribution of tamarisk and Russian-olive, examining environmental factors controlling their distributions, evaluating and monitoring control restoration strategies, and examining insect and avian diversity and abundance including neotropical migratory birds associated with a range of riparian vegetation patch types.

**Explaining and Predicting Distributions of US/China Invasive Plants:** The US and China are major sources of exotic and invasive species for one another due to climate similarities, historic isolation, and recent and rapid expansion of trade and travel. USGS scientists along with colleagues at the University of Wisconsin-Madison and the national Geomatics Center of China, are developing information on the distribution and environmental preferences of species native to one of the countries that have become invasive in the other. They are working to predict potential range and understand the factors that limit species distribution. A pilot study on the invasive tree, Chinese tallow, suggests it has the potential to expand considerably, farther to the north than the current distribution in the US.

**Remote Sensing of Invasive Aquatic Plants:** Aquatic managers and scientists require detailed and time-specific information on the distribution and abundance of invasive aquatic plants. USGS scientists are using satellite remote sensing to track aquatic weeds over large and difficult to access areas. Recently published work documented the rise and fall of the world's largest water hyacinth infestation in Lake Victoria, East Africa. Currently, efforts are underway to understand the dynamics of curly-leaved pondweed in Lake Sharpe, a major reservoir of the Missouri River in South Dakota.

**African Clawed Frog in Southern California:** Introductions of exotic species often have unexpected ecological consequences, and understanding the complex ways in which they may affect native ecosystems is critical to management solutions. USGS researchers and their colleagues recently reported on two different topics relating to the introduced African clawed frog (*Xenopus laevis*) in southern California: its parasites and its role as novel prey for native species. Their

findings indicate that as a transporter of exotic parasites, introduced African clawed frogs may pose more of a risk to freshwater fish than to terrestrial frogs. Additionally, where native amphibians have declined, African clawed frogs may represent a possible replacement food resource for some native species of semi-aquatic predators, such as the two-striped garter snake, a species of concern.

**Introduced Predators Transformed Subarctic Islands from Grassland to Tundra:** A team of USGS and USFWS biologists and academic collaborators found that introduced arctic foxes severely reduced seabird breeding colonies in the Aleutian Islands, initiating an ecosystem-wide trophic cascade that reduced the transport of nutrients from ocean to land, created nutrient-impooverished soils, and transformed a dense grassland, to low-growing tundra. Because some islands remained fox-free, the researchers were able to compare fox-infested with fox-free islands and closely examine the effects of the introduced predators. Seabirds transfer nutrients from the ocean to the land by feeding on marine fish and invertebrates and spreading nutrient-rich guano around the islands. The researchers found that the density of breeding seabirds on fox-free islands was two orders of magnitude higher than on fox-infested islands. The resulting difference in nutrient inputs was reflected in soil phosphorus levels that were more than three times higher on fox-free islands. The vegetation on the islands also showed significant differences in nutrient content. Evidence that more ocean-derived nutrients were cycling through the ecosystems of fox-free islands than on fox-infested islands came from analyses of nitrogen isotopes in soil, plant, and animal samples.

**Predicting Non-Native Plant Invasions:** Using non-native plant distribution information, GIS data on current habitat conditions, and modeling techniques, scientists from USGS and University of California, Davis, predicted a relatively low level of non-native plant invasion in Yosemite National Park. Predicted occurrence maps can help managers plan for early detection and monitoring to protect park ecosystems.

**Red Brome in North America: Possible Modes for Early Introductions, Subsequent Spread:** A USGS Ecologist is the author of a recent paper which traces the early introductions and subsequent spread of red brome in western North America. Although invasions by exotic plants have increased dramatically as human travel and commerce have increased, few have been comprehensively described. Understanding the patterns of invasive species' spread over space and time will help guide management activities and policy. Tracing the earliest appearances of an exotic plant reveals likely sites of introduction, paving the way for genetic studies to quantify founder events and identify potential source populations. Red brome (*Bromus rubens* subsp. *madritensis*) is a Mediterranean winter annual grass that has invaded even relatively undisturbed areas of western North America, where it threatens native plant communities. Herbarium records and historical reports suggest that red brome was first introduced to North America through California during the influx of immigrants and cargo in the 19th century. These results challenge the most frequently cited sources describing the early history of this grass and suggest three possible modes for early introductions: the California Gold Rush and Central Valley wheat, southern California shipping, and northern California sheep. These introductions may well be continuing to this day, either directly from the Mediterranean region, or indirectly, from populations established in other regions. Subsequent periods of most rapid spread into new areas, from 1930 to 1942, and of greatest spread into new regions, during the past 50 years, coincide with periods of 'warm' Pacific Decadal Oscillation regimes, which are linked to increased winter precipitation in the southwestern USA and northern Mexico.

**Weeding out Buffelgrass in the Sonoran Desert:** Introduced from Africa into south Texas in the 1940s and extensively in Sonora, Mexico since the 1960s, buffelgrass has recently begun to spread vigorously in southern Arizona, invading even remote backcountry areas of national parks and wildlife refuges. The invasive nonnative perennial grass can burn in any season and is capable in most years of producing fuel loads orders of magnitude greater than red brome, a nonnative annual grass that has fueled fires in both the Mojave and Sonoran deserts. A study by USGS scientists at Saguaro National Park is investigating the most cost-effective techniques for removing buffelgrass and restoring the desert's native vegetation.

**Native Grasses vs. Nonnative Invasive Cheatgrass:** A joint project by USGS, NPS, and BLM seeks to determine whether several native grasses can be used to battle invasive cheatgrass following prescribed fire in ponderosa pine ecosystems in the BLM-NPS jointly managed Grand Canyon-Parashant National Monument in northwestern Arizona. The project is funded by the National Interagency Fire Center's Joint Fire Science Program.

**Tamarisk:** USGS ecologists are studying neotropical migratory birds and how they utilize habitat along the Colorado River, including the invasive tamarisk (saltcedar) as well as native vegetation habitats. The objective of this research is to fill information gaps regarding revegetation and restoration in the context of avian community responses to tamarisk control efforts, elucidating similarities and differences between habitats within the Lower Colorado River system. This will include: synthesizing existing information, conducting new research on candidate restoration targets and implementing scientifically rigorous avian monitoring designs for site-specific studies in cooperation with partner agencies and other stakeholders.

**Mechanical Removal:** The USGS scientists are conducting the 4<sup>th</sup> year of an ambitious research project to remove non-native predatory and competitive fish from a 14 mile reach of the Colorado River in Grand Canyon National Park that is critical to the recovery of the endangered humpback chub. To date, about 18,000 rainbow trout, brown trout, and other exotic fish have been removed using electroshocking equipment. Surveys of humpback chub are being conducted concurrently to determine if and when an effect on recruitment and survival is detected. This research is being conducted in support of the Glen Canyon Dam Adaptive Management Program.

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## ***FIRE***

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**Fire Science in Voyageurs National Park:** USGS scientists in collaboration with University of Wisconsin biologists are conducting research on the short-term effects of fire related to mercury mobilization into aquatic food webs in Voyageurs National Park, Minnesota. Study objectives include determination of whether forest fires combusting mercury found in forest soils will introduce a pulse of methylmercury (MeHg) into lake waters, resulting in an increase of MeHg at the base of an aquatic food web. A 2004 lightning-ignited wildfire burned 80% of a small watershed. Soil samples across gradients of fire severity, combined with collecting age-1 perch from the adjacent lake will give researchers insight regarding fire-induced mobilization of MeHg.

**Hydrologic and Erosional Responses of Burned Watersheds:** The enhanced probability of catastrophic wildfires in the western United States and elsewhere in the world has increased the need to understand the flooding risk and the erosional and depositional responses of burned

watersheds. In addition, surface water flowing from burned areas may carry increased levels of sediment, organic debris, and chemicals that may contribute to significant degradation of municipal water supplies and aquatic habitats. This USGS project has three main thrusts: (1) investigating the relation between rainfall intensity and peak water discharge from burned watersheds, a relation that depends on the size of the rainstorm, the size of the burned area and burn severity, and the changes in infiltration capacity of the soil; (2) investigating the hillslope and channel erosion and deposition processes after wildfire with a focus on predicting these processes on a watershed or landscape scale rather than on a single hillslope plot or cross-section scale; and (3) examining the water quality impacts of wildfire and are synthesizing post-fire water-quality sampling protocols.

**Effects of Wildfire on Water Quality in Glacier National Park:** Wildfires burned over 135,000 acres in Glacier National Park (GLAC) during summer 2003, more than 30 times the annual average. As park managers begin to reassess fire management policies following the fire, it has become clear that there is a need for specific knowledge concerning the ecological effects of wildfire, particularly on water quality. Post-burn effects on water quality may include increased surface runoff and erosion, and leaching of nutrients, carbon, and metals from ash and soils. This study will document the effects of wildfire on water quality in streams draining areas in GLAC that burned in 2003, with emphasis on the effects of burn intensity. Predicting fire effects on water quality fulfills a critical need for the refinement of fire management in the National Parks as well as in other wildland areas.

**Post-Fire Hydrologic Hazards:** Wildfires drastically changed the hydrologic, hydraulic and geomorphologic characteristics of many Colorado watersheds in the summer of 2002. Detailed assessments were made of the short-term and long-term impacts of selected high-priority wildfires. Results of the analyses of short-term impacts provide information about the effects of fire on runoff and sediment from burned watersheds, flood-hazard maps, and debris-flow hazard maps. Longer-term runoff characteristics that reflect post-fire watershed recovery and stabilizing hydrologic conditions expected to develop over a period of several years after the fire also were analyzed.

**Evaluation of Fire Effects and Fire Surrogate Treatments in the Sagebrush Biome:** Federal agencies use a variety of management methods on western rangelands to alleviate the potential for fire, restore native plant communities, and create habitat for wildlife. We and other collaborators are studying these treatments (prescribed fire, herbicides, cutting and removal of woody species, and brush beating with a mechanical device) in multiple western states to determine the conditions under which sagebrush-steppe communities recover on their own following treatment, versus conditions that require active restoration. The program specifically considers how treatments influence the primary ecosystem processes that contribute to recovery. This information also is important to understanding the characteristics of these systems that facilitate or resist the spread of invasive plants or the encroachment of pinyon-juniper woodlands. This research also will determine the habitat components that influence the distribution and abundance of wildlife species. Information synthesis and exchange is an essential part of these collaborative studies

**Evaluation of Habitat Treatments:** Recovery of greater sage-grouse and other sagebrush-obligate species depends on preserving and restoring sagebrush habitats at landscape scales. Prescribed fire and mechanical and chemical treatment of vegetation contribute to the loss and fragmentation of sagebrush stands, but, if used appropriately, these techniques may aid restoration. Furthermore, the National Fire Plan mandates reductions in hazardous fuels to decrease the likelihood of large rangeland fires and to restore these areas to historic structure and function. USGS scientists are evaluating changes in vegetation and in greater sage-grouse food items (both plants and

invertebrates) after Bureau of Land Management fuels management treatments carried out at sites in Idaho, Nevada, and Wyoming between 1997 and 2004. We also are developing and testing assessment protocol for determining extent and dominance of cheatgrass, a major contributor to wildlife, in the Great Basin. This research will help determine which lands require restoration and which are resilient enough to recover on their own after the fuel treatments.

**Fire Impacts in the West:** USGS scientists are initiating studies to evaluate the impacts of fire on wildlife and their habitats. Studies include 1) Effects of prescribed and wildland fire on aquatic ecosystems in western forests; 2) Fuels management and wildlife habitat: BLM Fire Science; 2) BLM's Emergency Fire Rehabilitation (EFR) Monitoring in the Intermountain West; 2) road- and mid-scale mapping of sagebrush habitats in the Intermountain West: an hierarchical approach; and 5) Designing an experiment to evaluate effects of fire and fire surrogate treatments in sagebrush environments.

**Fire and Invasion of Annual Grasses:** Large portions of the rangelands once dominated by sagebrush and other native shrubs, grasses, and herbaceous plants, are being replaced by exotic and invasive annual grasses following major wildfires. Exotic grasses have invaded many regions of the west. These grasses are typically Eurasian annuals that perpetuate fires on a nearly annual basis, threatening human communities, wildlife, and traditional ranching practices. Such rapid fire cycles are having a significant impact on the native communities of plants and animals that often have few evolved defenses against fire and are unable to survive frequent successive burns. USGS researchers are conducting detailed studies to better understand how increased fire size and frequency affect arid ecosystems of the west, how fire related, and how to protect native plants and animals from further impacts of invasive annual grasses.

**Fire and Invasive Annual Grasses on Southwestern Rangelands:** USGS scientists are investigating the interactions between fire and soil nutrients over three ecosystems currently dominated or threatened by invasive annual grasses in western North America - Great Basin shrubland, Mojave Desert scrub and Sierra Nevada yellow pine forest. Common factors driving the fire/annual grass cycle in these ecosystems will lead to generalizations widely applicable beyond the ecosystems under study. In addition, each of these systems has unique features that contribute to the dominance of invasive annual grasses, and elucidation of these will contribute to a broader understanding of the problem.

**Fire and Urban Expansion at the Wildland Interface:** Throughout the west human communities continue to expand blend into natural communities dominated by forests, grasslands, shrubland on the coast of California where an increasing number of communities are developed in shrublands called chaparral. This development is not without risk, as California chaparral ecosystems burn in large landscape-scale crown fires that are necessary for the ecology of these systems but pose a threat to human populations. USGS research shows that many species in these systems are highly dependent on recurrent fire because some seeds require smoke to induce germination. Unlike western forests where a century of fire exclusion has led to fuel accumulation and a risk of catastrophic wildfires, USGS research has shown that large, intense fires have burned in chaparral ecosystems for numerous decades. They occur, in league with powerful Santa Ana winds, as frequently today as before widespread fire management aimed at fire exclusion. Research is providing critical information about the ecology and natural history of these ecosystems to advise land managers about appropriate fire management policy in shrubland-dominated landscapes. Unlike other plant communities, the use of prescribed fire in these areas is not necessary for ecosystem health, nor is it able to prevent large-scale fires.

### **Restoring Habitat for Shrub-Steppe Birds after an Extensive, Habitat-Altering Wildfire:**

Effects of prescribed burns and wildfires, and of restoration efforts following fires, have become one of the most controversial management issues in the intermountain west. A series of well-designed studies documenting the effects of fire on wildlife and evaluating alternative post-fire actions are needed. USGS is conducting a small version of such a study for the Hanford Reach National Monument/Saddle Mountain National Wildlife Refuge in southeastern Washington, where a wildfire burned 164,000 acres of shrubsteppe in June 2000. Birds are considered a particularly important resource on the area and thus subject of this study.

### **The Ecological, Hydrological, and Geological Consequences of Burn Severity and Social**

**Application of those Results:** Research results demonstrate that current, operational methods for describing burn severity used by post-fire Burned Area Emergency Rehabilitation (BAER) teams at the Cerro Grande fire underestimated the amount of area moderately affected by fire and overestimated the area highly impacted by fire. Landsat-derived burn severity (dNBR) and AVIRIS-derived post-fire land cover maps detected fine-scale variability in landscape change caused by fire in greater detail than current, operational methods applied by other federal agencies. This increased detail allowed new scientific approaches to be applied to characterizing the biotic and abiotic consequences of fire, including 1) extending field-based measures of vegetation cover, wildlife populations, erosion, and landslide hazards with remote sensing data, and 2) examining the importance of spatial patterns of burn severity. This Project has resulted in the development of new scientific methods to characterize the impact of fire on the landscape by integrating field-based science with remote sensing technologies. Our multi-factor, spatially based framework for defining burn severity holds potential for improved understanding of fire effects and post-fire management actions.

**Burn Severity Mapping in Alaska:** USGS scientists have developed the capability to routinely map burn severity patterns and changes over time within a fire and deliver standardized map products. A cooperative project between the Fish and Wildlife Service and the USGS will produce an “extended assessment” of burn severity for 15 fires that occurred in Alaska in 2004. The USFWS will receive maps that include the fire perimeter, and a dNBR value for each 30 meter pixel within the fire.

**Fire Fuels Assessment:** USGS scientists, in cooperation with the USFS, conduct the LANDFIRE project. LANDFIRE is a 5-year, multi-partner wildland fire, ecosystem, and fuel mapping project. This project will generate consistent, comprehensive, landscape-scale maps and data describing vegetation, fire, and fuel characteristics across the United States. These maps are produced at scales fine enough to assist in prioritizing and planning specific hazardous fuel reduction and ecosystem restoration projects. The consistency of LANDFIRE methods ensures that data will be nationally relevant, while the 30-meter grid resolution assures that data can be locally applicable. LANDFIRE meets agency and partner needs for data to support landscape fire management planning, prioritization of fuel treatments, collaboration, community and firefighter protection, and effective resource allocation.

**Monitoring Trends in Burn Severity:** Burn severity mapping using satellite imagery has been shown effective, providing needed and timely data to assess effects of fire on many environmental concerns from air quality to soil erosion, water yield, trace gas emission and restocking, and biodiversity dynamics. USGS scientists have begun a 6-year cooperative effort to map burn severity of fires occurring since 1982 and future fires using the Differenced Normalized Burn Ratio

approach at 30m spatial resolution for all fires that are 1,000 acres or greater for the western United States. Data products include maps of burn severity, fire perimeters, tabular data summarizing acres burned by severity classes and by vegetation cover types, and tabular data of burn severity trends stratified by fuel treatment projects and other socio-economic stratifications. Map products will be distributed to field users via web-based map servers, data and map products archived permanently at existing USGS facilities. Technology transfer: documentation, training workshops, web-based training modules, as well as peer-reviewed journal publications of analysis and findings.

**Fire Danger Monitoring:** For over a decade the USGS has provided the USFWS vegetation condition information for fire danger assessment in Alaska. Every week during the Alaskan growing season the USGS EROS uses 1-km resolution satellite imagery from the Advanced Very High Resolution Radiometer (AVHRR) sensor to produce an updated map of vegetation condition. The vegetation condition information is used to derive relative greenness, departure from average, live shrub moisture, and fire potential maps. The USFWS, in partnership with NPS, BLM, USFS and the Alaska Division of Forestry, posts the vegetation condition information on the World Wide Web. USGS scientists are currently linking the existing AVHRR time series to more advanced satellite technology to provide continuity of observations far into the future.

**Fire Akin to Herbivores in Shaping Ecosystems Globally:** Wildland fire is commonly regarded as an ecosystem disturbance. A USGS scientist and colleague from South Africa contend that fire is more than a disturbance, such as cyclones or floods, but a natural ecosystem process much like herbivory; and as such is critical to the proper functioning of many systems. In their study fire, like plant eaters, “feeds” on complex organic molecules and converts them to organic and mineral products. Fire differs from herbivory in that it regularly consumes both dead and living material, requires no protein for its growth, has broad dietary preferences, and commonly consumes plants that are inedible for herbivores. The researchers suggest that models that attempt to understand global vegetation distribution based solely on climate and soils are likely to misjudge some landscapes that owe their vegetation distribution to historical patterns of burning.

**Fire Effects on a Mountain Beaver Population:** In 1995, a 5,000-hectare wildlands fire on the Point Reyes peninsula, California, provided researchers at the USGS and NPS an opportunity to assess the pre-fire distribution and population size of mountain beavers within the burn area and evaluate their survival and recovery. The fire burned 40% of the known range of the Point Reyes mountain beaver, including much of what was believed to be prime habitat of this isolated subspecies. Less than 2% of an estimated 5,000 mountain beavers survived the fire, and the researchers estimate recovery may take 15-20 years.

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## **GENETICS**

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**Greater Sage-Grouse Genetics: A Multilocus Genetic Survey of Sage-Grouse Across Their Range:** The objective of this study is to complete DNA sequence analysis of one mitochondrial region and microsatellite analysis of seven nuclear regions in Sage-Grouse sampled across their entire range, including 11 states and two (Canadian) provinces. These data will include boundaries between Greater and Gunnison Sage-Grouse populations as well as the two described subspecies of Greater Sage-Grouse. In addition to recognized boundaries between subspecies/species, these data will provide information relevant to an understanding of gene flow, genetic diversity and

evolutionary history between many additional populations. Because the same data are being collected across the entire species range, it will be possible to use the genetic landscape so generated to make direct comparisons between all populations encompassed by this survey, thereby facilitating species-wide management decisions that are based on a consistent type of data.

**Gunnison Sage-Grouse Genetics:** Population Genetics of Gunnison Sage-Grouse using nuclear microsatellites: Previous genetic studies have compared Gunnison Sage-Grouse populations to Greater Sage-Grouse populations in Colorado and have shown that Gunnison Sage-Grouse population are much more structured (less gene flow among them) and have much less genetic diversity than Greater Sage-Grouse populations. These studies have focused on only four of the seven Gunnison Sage-Grouse populations and have had relatively small sample sizes per population (18 – 20 samples in some populations). Because the amount of variation in genetic makeup among the four sampled populations was very high, the amount of genetic variation present in unsampled populations remains difficult to predict, and it would be helpful to increase sample sizes in all sampled populations. With this goal in mind, colleagues in the field have collected additional tissue samples of Gunnison Sage-Grouse. The objective of this study is to characterize the genetic makeup of all seven Gunnison Sage-Grouse populations using both mitochondrial and nuclear DNA markers. This information will provide managers with a measure of gene flow and connectivity among populations and will document levels of genetic diversity for each population. It will also provide the baseline genetic information necessary should managers consider translocation as a management option.

**Sage-Grouse: Using DNA as an Individual Marker to Estimate Sage-Grouse Population Parameters Using Mark-Recapture Analysis:** Capture-recapture (CR) methods are used to estimate population abundance, survival probabilities, population trends, and obtain movement information. Often, CR is the only approach to obtaining reliable quantitative population information for science and management. It has now become feasible to consider using an individual's unique DNA as its mark. Such DNA "marking" has great potential advantages when "capture" can be related not to the animal, but, for example, to hairs, feathers, or feces. Recognizing this potential, biologists have explored some aspects of DNA-based application of CR models (DNA-CR) to estimate population parameters. The Gunnison Sage-Grouse is a great example of a species for which this methodology can be useful. A significant problem with management of sage-grouse in general is a lack of valid population size and survival estimates. USGS scientists will use DNA-CR to estimate population sizes of Gunnison Sage-Grouse using feces as a source of recapture. We will then compare rigorous population estimates based on DNA-CR with lek count data to determine how well they can be used as an index to population size estimation.

**Sage-Grouse: Analysis of the Mating System of Gunnison Sage-Grouse Using Paternity Analysis:** Because of the lek mating system, size of Gunnison Sage-Grouse populations has been difficult to determine using traditional methods. This study will serve to estimate the proportion of Gunnison sage-grouse males that breed annually by assigning parentage to chicks using molecular genetic techniques. This has implications for determining the effective size of the population, and consequently, the minimum size of a viable population.

**Trumpeter Swans: Comparison of Trumpeter Swan Populations Using Nuclear and Mitochondrial Genetic Markers:** The existence or extent of genetic interchange between the Rocky Mountain Population and the Grande Prairie –Peace River Populations of Trumpeter Swans remains unknown, yet may influence management practices and whether the flocks should be

managed in the aggregate or as 2 distinct entities. This study will evaluate the distribution of genetic variation among populations across the range. With increasing pressure on managers to make difficult decisions about whether populations are unique or not, and which populations to use as sources for translocation and restoration attempts, resolution of this issue has become vital.

**DNA Analyses to Guide Management Strategies for Larch Mountain Salamander:** The Larch Mountain salamander (*Plethodon larselli*) is a species endemic to the Pacific Northwest that faces considerable threats due to habitat destruction. They are a completely terrestrial species that is considered one of the rarest amphibians in the PNW because of its restricted range along a very narrow corridor in the Columbia River Gorge and its patchy distribution in the Cascade Mountain Range from northern Oregon to south-central Washington. In an effort to facilitate the development of conservation strategies, the USGS and collaborators used DNA analyses to examine differences among populations of Larch Mountain salamanders. Results of nuclear and mitochondrial DNA data suggest that while most populations of Larch Mountain salamanders are significantly different from one another, there was substantially less differentiation among populations located north of the Columbia River than those to the south. These findings and others obtained in the research suggest that it may be advisable to designate distinct management strategies for northern versus southern populations.

**Influence of Barriers on Genetic Variation of Coastal Cutthroat Trout:** Because human land-use activities often result in increased fragmentation of habitats, a better understanding of the effects of fragmentation on the genetic heterogeneity of animal populations may be useful for effective management. The USGS and university collaborators recently co-authored a publication in which they used microsatellites to examine the genetic structure of coastal cutthroat trout in Camp Creek, an isolated headwater stream in western Oregon. Their objectives were to assess coastal cutthroat trout population structure in a small stream network and to evaluate the effects of fish passage barriers on the trout's genetic variation. The dispersal barriers in Camp Creek strongly influenced coastal cutthroat trout genetic structure and were associated with reduced genetic diversity and increased genetic differentiation. Results indicate that Camp Creek coastal cutthroat trout exist as many small, partially independent populations that are strongly affected by genetic drift. The authors concluded that in headwater streams, barriers to movement can result in genetic and demographic isolation leading to reduced coastal cutthroat trout genetic diversity and potentially compromising long-term population persistence. When habitat fragmentation eliminates gene flow among small populations, similar results may occur in other species. The research suggests that managers acknowledge the significance of habitat connectivity and recognize the potential effects of barriers to movement on animal genetic structure.

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## **WILDLIFE HEALTH**

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**Rabies and Bat Populations in Human-Occupied Buildings:** The dynamics of rabies transmission in bat populations that roost and live within cities is being investigated using Fort Collins, Colorado, as the case study. USGS biologists are working on this project in collaboration with Colorado State University, the Centers for Disease Control and Prevention, and the National Science Foundation. Rabies commonly circulates in populations of these bats, but these animals appear to have the capacity to develop immunity to the disease. This 5-year study will be

completed in 2006. Final results will include a new model for rabies transmission in bats and are expected to be of considerable interest to public health agencies and bat conservationists.

**Avian Cholera in Eared Grebes on the Great Salt Lake:** The USGS, USFWS, and Utah Division of Wildlife Resources (UDWR) investigated and managed the mortality of an estimated 30,000 sick and dead (only 1 percent were sick, the rest were dead) eared grebes on the main body of the Great Salt Lake. The total estimated population of eared grebes on the lake was 500,000. Avian cholera was diagnosed in all birds tested. Previous outbreaks of avian cholera on the Great Salt Lake were documented in 1994, 1995, 1998, and 2002 with estimated losses ranging from 1,000 to 44,000 birds, mostly eared grebes. UDWR and USFWS personnel monitored the mortality from the onset in October until it ended in early December.

**Chronic Wasting Disease:** The USGS, in collaboration with the University of Wyoming and the Wyoming Game and Fish Department, is developing a CWD-positive tissue bank to gain a better understanding of this disease. Thirty six wild-caught cervids (12 elk, 12 mule deer, and 12 white-tailed deer) were orally inoculated with CWD at the Tom Thorne/Beth Williams Wildlife Research Center (formerly the Sybille Wildlife Research Center) in Wheatland, Wyoming. Animals will be euthanized and tissues harvested at 6-month intervals, post-inoculation. Harvested tissues will be made available for reviewed research projects and for testing/validation of CWD assays. USGS researchers will also collaborate with the Colorado Division of Wildlife, the University of South Carolina, and the Wildlife Conservation Society to apply modern statistical epidemiological theory to long-term CWD data sets collected by the State of Colorado. In this effort to rapidly advance our understanding of the factors driving the dynamics of CWD epidemics in space and time, researchers will draw upon analytical theory from epidemiology and spatial analysis to develop new approaches to analyze geo-referenced CWD data. The goal of the analysis is to determine the extent to which CWD distribution can be explained by landscape and geographic features.

**Data Clearinghouse for Chronic Wasting Disease:** The CWD Data Clearinghouse (CWDDC) represents the first nationwide system that will provide common access to scientific, technical and geospatial information on CWD. The National Biological Information Infrastructure and NWHC developed a prototype CWDDC that was tested through trials of interactive on-line sessions involving 30 individuals from 15 state, federal, and non-governmental agencies. The prototype was demonstrated at the 2004 International Association of Fish and Wildlife Agencies meeting, offering the opportunity for hands-on access and feedback. From the trials and the feedback, prototype designers determined that the current model could be enhanced to meet more user needs. Staff from the Wildlife Disease Information Node will demonstrate a working model with the enhancements during the 2nd International CWD Symposium in Madison, WI July 2005.

**Impact of West Nile Virus on White Pelican Colonies in Northern Montana, North Dakota and South Dakota:** The USGS, in cooperation with the USFWS, is in the second year of a project that assesses the affects of West Nile virus (WNV) on three pelican nesting colonies in North Dakota, South Dakota, and Montana. Between June 29 and August 16, 2004, 119 pelican carcasses were collected in South Dakota and Montana for examination, West Nile virus sample collection, and analysis. Breeding adult pelicans at the third site in North Dakota abandoned their nesting colony. The first positive WNV cultures and serology were from birds collected in South Dakota and in Montana in July 2004. After the initial positive WNV sample was confirmed at each site, a high frequency of the remaining birds collected were WNV positive (89 percent in SD and 71 percent in MT).

**West Nile Virus (WNV) in the West:** USGS scientists developed a model to predict where disease outbreaks will most likely be expected in Arizona. Hotspots were identified around Phoenix and Yuma and preliminary data appear to validate the model. Technical support has been provided to state and federal health workers with WNV surveillance and prevention responsibilities throughout the southwestern US.

**Measuring the Effects of West Nile Virus on American Kestrel Populations in Colorado:**

USGS scientists are monitoring kestrels and burrowing owls to assess the annual inception and level of occurrence of WNV among these birds, and compare survival and reproduction parameters between infected and non-infected individuals within the population. In 2004, the USGS began an investigation to assess the prevalence and potential effects of WNV on wild American kestrel populations along the Front Range of Colorado. A total of 116 individual adults and 262 young were sampled throughout the breeding season for a total of 747 WNV samples. While the WNV was not detected in serum or oral swabs, 97.4 percent of the blood sampled adults captured in this study tested positive for WNV antibodies, suggesting prior exposure to the disease.

**West Nile Virus and Other Avian Pathogens in Greater Sage-Grouse:** USGS is evaluating the exposure of greater sage-grouse and other vertebrate species within sagebrush habitat to WNV and other pathogens to determine if they are affected by WNV and what role they may play in the transmission of the disease. Field research has been conducted at study sites in Nevada, Oregon, and California. To date, WNV has been found in 1 of 13 greater sage-grouse carcasses examined, but samples from live greater sage-grouse and alternate hosts (passerines and feral horses) have not shown evidence of exposure to the virus. Laboratory studies indicate that chukar partridge may amplify the virus making them a useful sentinel for WNV in the field.

**West Nile Virus and Hawaiian Birds:** The introduced vector of avian malaria, the Southern House Mosquito *Culex quinquefasciatus*, is widely distributed throughout the islands and is a recognized enzootic vector of West Nile Virus. With a well distributed vector in place and large populations of native birds, West Nile Virus has the potential to sweep through Hawaii with devastating impact to native birds and human health. USGS scientists have conducted studies on the relative vector competence of Hawaiian *Culex quinquefasciatus* for West Nile virus and the level of susceptibility of Hawaii Amakihi to West Nile Virus as a model for evaluating its potential impact on threatened and endangered forest birds. Preliminary analysis suggests about 30% mortality in challenged birds but necropsies revealed little gross pathology. Most birds underwent a transient drop in food consumption which may be a significant factor in wild bird survival.

**Risk Assessment for West Nile Virus in Hawaii:** USGS is collaborating with Hawaii Department of Public Health (HIDOH) to conduct serosurveys (serologic tests on populations) for flaviviruses in Hawaii in an attempt to detect WNV as early as possible if it is transported to the islands from the mainland by air. Scientists have collected blood samples from 405 birds including java sparrows, laceneck doves, house finches, house sparrows, zebra doves, and red-crested cardinals from the Honolulu International Airport. This wild bird surveillance supplements mosquito surveillance and abatement activities being done by HIDOH. USGS is also conducting laboratory studies, in partnership with the State of Hawaii and the USFWS, to determine the suitability of non-native Hawaiian birds, such as java sparrows, laceneck doves and house finches, to serve as amplifying, reservoir hosts or sentinels for WNV in Hawaii. Another laboratory study is involved with investigating the susceptibility of native honeycreepers to WNV by using the amakihi.

**Plague: Ecology of Plague in Black-Footed Ferret and Prairie Dog Populations:** This USGS study is directed toward gaining further understanding of the ecology of plague during periods between epizootic outbreaks of the disease in prairie dogs. If enzootic plague is depressing populations of small mammals, an ambitious effort to remove plague may allow increased population densities to develop over a several year period. This study will attempt to reduce the incidence of plague (or eliminate it) from test areas by reducing the population of fleas which transmit the disease. The initial objective of this study is to assess efficacy, longevity, and cost of flea control using deltamethrin delivered as dust within burrows and to measure population responses of prairie dogs and associated mammals.

**Sylvatic Plague in Prairie Dogs and Black-Footed Ferrets:** USGS scientists are continuing research and development of vaccines against sylvatic plague in prairie dogs and black-footed ferrets. An injectable vaccine has been shown to be successful in preventing plague experimentally in endangered black-footed ferrets, and was deployed this past year in a field experiment in collaboration with the Fish and Wildlife Service. In this experiment, half of captive-bred ferrets released to the wild at several locations were vaccinated, and the other half served as unvaccinated controls. This study will evaluate the efficacy of the vaccine in the field and compare survival between vaccinated and unvaccinated ferrets. A different recombinant vaccine that can be delivered orally to prairie dogs has shown promise in experimental studies. Studies to improve the efficacy of this recombinant vaccine and its incorporation into baits are continuing.

**Avian Disease Investigations in the Salton Sea, California:** USGS scientists are characterizing *Pasteurella multocida* isolates from eared grebes that have died at the Salton Sea and elsewhere, by using genomic fingerprinting method called amplified fragment length polymorphism (AFLP) analysis. Researchers will compare AFLP patterns generated from bacterial isolates from multiple bird species and from isolates obtained from birds obtained elsewhere within the flyway, in an effort to understand the epizootiology of avian cholera.

**Selenium Exposure in Arctic Avian Species:** In collaboration with the Alaska SeaLife Center and the USFWS, USGS is conducting studies of selenium exposure in sea ducks. Blood samples have been collected from six species of sea ducks in Alaska and analyzed for selenium. The relationship of blood selenium concentrations and measurements of oxidative stress in plasma are being studied in long-tailed ducks and common eiders. An experimental study of selenium exposure in common eiders has been completed.

**Survey of Native and Non-Native Fish from Colorado River Tributaries in Grand Canyon:** USGS scientists are examining fish in the tributaries of the Colorado River below Glen Canyon Dam and above Diamond Creek. Previous field studies conducted by NWHC and Arizona Game and Fish Department revealed that the exotic Asian fish tapeworm *Bothriocephalus acheilognathi* was in the lower Colorado River and infected a large percentage of the endangered humpback chub (*Gila cypha*) examined from that river. Laboratory infections of bonytail chub (*Gila elegans*) indicated that the parasite caused retarded growth and earlier death in infected fish when compared with uninfected controls. The parasite can only reproduce in warm waters; therefore, it is not able to reproduce in the mainstem Colorado River. Surveys of fish from the tributaries will provide information on the extent of the parasite's range and also whether other exotic parasites are present in the warm tributaries feeding the mainstem Colorado River and whether there is a danger in parasites spreading from the warmer waters to the mainstem if waters are warmed in the Colorado River below Glen Canyon Dam.

**Chytrid Fungus Studies in National Parks:** USGS is conducting a watershed analysis to determine the distribution of the chytrid fungus at Yosemite National Park and Point Reyes National Seashore and the role of the fungus in amphibian extirpations.

**Chytrid Fungus in the Pacific Northwest:** USGS is using occupancy models to analyze geographic data to determine the regional geographic pattern of the chytrid fungus in native amphibians and introduced bullfrogs found in the Pacific Northwest. This study will also determine the relationship between geographic distribution of the fungus and environmental gradients, such as climate, human disturbance, and bullfrog presence.

**Laysan Ducks:** USGS provided veterinary care for translocation of endangered Laysan ducks from Laysan Island, HI, to Midway Atoll. This was the first attempt to re-establish populations of this duck since 1967. USFWS has deemed it critical that additional populations be established beyond Laysan Island, which is the only place where this endangered duck species exists.

**Avian Influenza:** USGS scientists are enhancing their molecular capability to detect H5N1 avian influenza at the National Wildlife Health Center (NWHC). This technology will enable USGS to screen wildlife submissions for the highly pathogenic avian influenza (HPAI) strain that is currently plaguing the domestic poultry industry in Southeast Asia. The H5N1 HPAI has also been attributed to several human deaths and mortality in several species of wildlife. USGS is preparing to conduct targeted surveillance of waterbirds and asking conservation agencies to report waterbird mortality to the NWHC.

**Technical Assistance in Fish Health:** The USGS continued to provide technical assistance in response to requests from Department of the Interior bureaus, tribal and state fisheries agencies, and private sector aquaculture. The assistance is in the form of technical support, laboratory services, education and training, technology transfer, and rapid response concerning fish disease and other health issues affecting wild salmonid and other fish populations, including threatened, endangered, and sensitive species. Activities under this project include: research and development of specialized laboratory reagents and testing (diagnostic) tools, particularly in microbiological disciplines; teaching of short courses on use of specialized laboratory methods for fisheries; disease challenges and testing of disease treatment regimes; rapid response to investigate fish epizootics; sponsoring of symposia and coordination meetings; and routine professional communications in response to information requests.

**Ichthyophonus Infections of Yukon River Chinook Salmon:** Scientists at the USGS completed a five-year study on the prevalence and intensity of *Ichthyophonus* infections in returning adult Chinook salmon in the Yukon River. The study sampled Chinook at multiple sites within the Yukon system to assess prevalence of *Ichthyophonus* infection and disease severity and to relate annual changes to changes in river conditions (esp. temperature). Field studies confirmed that more than 25% of Yukon River Chinook salmon enter the river infected with *Ichthyophonus*. Infection prevalence remained relatively constant until fish reached the upper Yukon where it dramatically dropped to 10% or less. Clinical signs of disease were minimal when fish entered the river, but increased significantly when fish reached the middle river. Also, the parasite was disseminated and clinical disease was apparent in multiple organs among fish from later in the run, however, female spawn-outs collected from the upper Chena River showed little evidence of *Ichthyophonus* infection suggesting the fish had suffered a substantial pre-spawning mortality. Elevated river temperatures within and among years may be an important cause of increased disease among Yukon River Chinook salmon.

**IHNV Strain Differentiation and Online Database:** Infectious hematopoietic necrosis virus (IHNV) causes severe disease outbreaks among stocks of salmon and trout in the Western U.S. and numerous isolates of the virus have been obtained from wild and hatchery fish during the last 40 years. To date USGS scientists have genetically analyzed over 600 IHNV isolates from Washington, Oregon, Idaho, California, Alaska, and British Columbia. We observed dramatically different patterns of diversity and evolution of IHNV in different parts of its range, and under different conditions. The project has provided information to fish health managers about strains of IHNV within the various watersheds and fish culture facilities and has developed an online database of the genetic types of IHNV against which the emergence of new virus strains can be compared.

**Whirling Disease:** Whirling disease, and affliction of young salmonid fishes is caused by the microscopic myxosporean parasite, *Myxobolus cerebralis*. The disease, introduced in the United States in the 1950s, has now spread to 23 states where, in some cases, it has been associated with devastating declines in wild populations of rainbow trout. At the USGS, we are using genomic and microsatellite DNA sequences as well as random amplified polymorphic DNA (RAPD) markers, to determine the level of genetic diversity among strains of the parasite from locations throughout the U.S.. Additionally, we have developed RAPD and 18S ribosomal DNA markers for *Tubifex tubifex*, the oligochaete worm that serves as the alternate host for the parasite and is an essential part of the parasite life cycle. These markers can distinguish among worms from various geographic locations that appear morphologically identical but which have very different abilities to produce the actinospore stage of the parasite that infects fish. In addition USGS scientists are working on a project that will develop a limiting factors model of Tubifex habitat and then use hydraulic and sediment transport models to identify flow regimes and possible channel modifications to reduce Tubifex habitat. Field work and modeling have been started on Willow Creek and the Poudre River in Colorado.

**Spring Viremia of Carp Virus:** Spring viremia of carp virus (SVCV) is a fish rhabdovirus with the potential to cause large losses among native cyprinid fishes of North America. Formerly thought to be exotic to the continent, SVCV was isolated from koi carp at a commercial farm in North Carolina where it was associated with disease and high losses and also identified as the cause of a very large (several thousand metric tons) mortality that occurred among common carp in Cedar Lake, Wisconsin. These outbreaks are probably a result of the recent introduction of the virus into North America from Europe and Asia where the virus is endemic. A major research priority is to determine the susceptibility to SVCV of selected native cyprinids, and other select families, that are of special management concern to the USFWS. This work has begun and the information from this research will allow resource managers to make effective decisions to protect native resources and prevent the spread of this potentially devastating pathogen.

**Fish Immunology:** Scientists at the USGS are collaborating with immunologists at the University of Washington and the Institute for Systems Biology to screen recently completed genome sequences of fugu (pufferfish), zebrafish and Atlantic and Pacific salmon to search for homologous genes involved in the innate immune system. These genes have served as logical targets for quantitative PCR expression assays which have been developed at the USGS (e.g. interferon response genes, tumor necrosis factor alpha, etc.). These expression assays will serve as excellent predictors of general fish health and have been used to assess the response of fish to pathogens (e.g. IHNV) or to novel vaccines (e.g. DNA vaccines).

**Development of a Zebrafish Model to Study the Genetic Basis of Fish Disease:** To improve our understanding of the genetic basis of fish disease, we developed a model using zebrafish (*Danio rerio*) challenged with spring viremia of carp virus (SVCV) in a USGS Biosafety Level 3 containment facility. Our model closely approximates a natural infection of cyprinids with SVCV. The increasing use of zebrafish in biological research has resulted in the creation of a large number of mutant strains having specific gene deletions and the recent availability of the zebrafish genome sequence will lead to development of a broad range of gene expression assays. These tools offer unique opportunities to further our understanding of the genetic basis of viral pathogenesis and host response in fish.

**Susceptibility of Larval Herring to the Paralyzing Effects of Marine Biotoxins:** USGS scientists, in collaboration with researchers at NOAA-Fisheries, determined that exposure of larval Pacific herring to dissolved saxitoxin, a naturally produced marine biotoxin, causes severe impairments in sensorimotor function consisting of a loss in the ability of larvae to respond to mechanosensory stimuli as well as a reduction in spontaneous swimming activity. The observed deficits are dose-dependent with the largest effects occurring at one hour after exposure. Sensorimotor deficits due to saxitoxin exposure were reversible at all doses. Follow-up exposure studies are currently underway to determine the effects of natural levels of saxitoxin to adult and juvenile anchovies, a filter feeding forage fish that is appearing in Puget Sound in increasing abundances.

**New Parasite Detected in Puget Sound Rockfish:** USGS scientists, in collaboration with researchers at the University of Washington discovered two morphologically distinct forms of an intraerythrocytic parasite(s) in 45.7% of 119 rockfish (*Sebastes emphaeus*) from the San Juan Archipelago. Infection prevalence for both forms was 53% in males, 44% in females, and 33% in fish of undetermined gender. A binucleate “ring-stage” was present at all four geographic sites, with a mean prevalence of 45.7%, while mean prevalence of a larger gamont-like form from the same sites was 5.1%. The relationship of the two forms to each other could not be determined. The possibility of the two morphologic forms being two distinct species is supported by the observation that no difference in parasitemia was seen in the binucleate-form among sites (1.6% - 1.9%) while parasitemia of the gamont-like form varied significantly among sites, ranging from a high of 4% to a low of 0.1%.

**Emerging Pathogen in Puget Sound Rockfish:** USGS scientists, in collaboration with researchers at the University of Washington isolated *Ichthyophonus*, an emerging parasite in marine and estuarine fishes in the Pacific Northwest, from 12.5% of 304 Puget Sound rockfish sampled from five different sites in the San Juan Archipelago and Puget Sound in 2003. Significantly more females were infected (15%) than males (6.7%) but infected males were only detected at 2/5 sites while infected females were identified from all sites, with no difference in infection prevalence among the five sample sites. Genomic sequences from Puget Sound rockfish, Pacific herring and Yukon chinook salmon *Ichthyophonus* isolates were identical in both the A and B regions of the small subunit 18s ribosomal DNA, but were different from sequences obtained from *Ichthyophonus* isolated from four different species of rockfish.

**Mercury Concentrations in California Fishes:** The USGS is investigating mercury contamination in fishes inhabiting reservoirs on the western slope of the Sierra Nevada where historic goldmining operations were widespread. A recently completed survey of sportfish inhabiting Lake Natoma on the American River indicated that largemouth bass was highly contaminated with mercury whereas bluegill and redear sunfish contained much lower amounts of

this metal. Mercury concentrations in bass also showed strong correlations with fish age and size whereas, in sunfish, the correlations were much weaker. The higher concentration of mercury in adult bass than in adult sunfish was attributed to dietary differences (mercury is known to biomagnify through the food chain, and piscivorous bass feed higher on the food chain than do sunfish, which feed mostly on invertebrates).

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## **ECOSYSTEMS**

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**Hydraulic and Watershed Modeling of the Upper Osage River:** USGS scientists are employing hydraulic and watershed modeling techniques to assist managers in understanding linkages between hydrology and biota in the Upper Osage River watershed (located in eastern Kansas and western Missouri). Hydraulic modeling techniques can be used to quantify relations between discharge and the areal extent and distribution of various in-channel habitats and characteristics. The habitat information developed from the hydraulic modeling effort will be coupled with biological relations between aquatic populations and habitat (determined in separate, completed and ongoing biological studies) to estimate the extent of suitable aquatic habitat at different flows and quantify the characteristics of this habitat. Watershed modeling techniques will be used to predict and simulate the effects of numerous impoundments on low-flow sustainability and the frequency and duration of over-bank flood events. To the extent that land-use and hydrologic characteristics of presettlement conditions can be determined, the watershed modeling will also be used to qualitatively characterize the historical hydrologic regime under which native plant and animal species adapted. The calibrated watershed and flow-routing models will be used to identify and evaluate water management strategies that have the potential to minimize any adverse effects of upstream impoundments. The study will also determine the contributions and depletions from municipal, wildlife refuge, power plant, and other withdrawals; alluvial aquifers; irrigation; out-of-basin transfers; and flow regulation during dry-weather flows in the Marais des Cygnes, Little Osage, and Marmaton River basins.

**Mercury in North Dakota Wetlands:** An assessment of methyl-mercury contamination in depressional wetlands located in the Lostwood National Wildlife Refuge and Wilderness Area is being conducted by the North Dakota Water Science Center in collaboration with the North Dakota Department of Health, and USFWS. Samples for water and sediment quality were collected from 44 wetlands in April of 2003 and 2004. The wetlands vary in concentrations of mercury. Preliminary analysis of long-term patterns in mass accumulation of mercury in sediment core collected from the largest permanent wetland indicate that mercury deposition began to increase substantially starting in the late 1930's, and continued to variably increase until the time that the core was collected. USGS scientists deployed a mobile mercury lab, which contained atmospheric mercury monitoring instruments to the Refuge during the period April 27, 2004 to June 2, 2004. Preliminary analysis of data collected during this time period has clearly shown the signs of mercury emission sources near the Refuge.

**Ecological Assessment of the Missouri River:** This partnership between the USGS and the Environmental Protection Agency (EPA) facilitates the implementation of EPA's Environmental Monitoring and Assessment Program for Great River Ecosystems (EMAP-GRE). Overall program goals are to develop and demonstrate tools with which to assess the ecological condition of the Missouri, Upper Mississippi, and Ohio Rivers. The USGS is collecting baseline hydrologic,

chemical, biological, and ecological data at randomly selected sites for the Missouri River. A total of 24 sites on the Middle Missouri River (river miles 490 to 879) adjacent to Nebraska, Iowa, and South Dakota were selected by EPA for data collection during the FY2004 and will continue into FY2005. Actual sampling in the Middle Missouri River occurred during August 1 through September 22, 2004. Samples collected at each site included water-column chemistry, bottom sediment, periphyton, and macroinvertebrate samples. Fish communities were sampled using boat mounted electrofishing equipment.

**National Water Quality Assessment (NAWQA):** Fourteen major river basin study units within the USGS Central Region are active in the NAWQA program. NAWQA employs nationally consistent study design and methods so that water-quality conditions can be compared on a regional and national basis. Studies conducted in the program are long-term and cyclical so that trends in water quality can be analyzed to determine whether conditions are getting better or worse. Studies in the program relate human activities (contaminant sources, land and chemical use) and natural factors (soils, geology, hydrology, and climate) to water quality, aquatic life, and stream habitat so that findings are relevant to decision makers.

**Reconfigured Channel Monitoring and Assessment Program:** The CWSC has been monitoring several channel "restoration" (or reconfiguration) projects for a number of years. The objective of our monitoring and analysis is to determine the effectiveness of the restoration design and techniques. Since almost all of the reconfigured reaches we're monitoring have had "improved fish habitat" as one of the restoration objectives, this project might be of interest to recipients of the summary. The relatively large runoff this year has affected at least 2 of the monitored reaches. We plan, later this summer, to resurvey a few of those reaches to see what channel adjustments have occurred.

**Glacier Bay Ecology and Oceanography:** A multifaceted oceanographic monitoring program is being conducted by USGS scientists in Glacier Bay, providing basic data needed by Glacier Bay National Park managers. Sea floor habitat was mapped and is being geologically classified. Animal-habitat relationships are being investigated with video images collected in association with the geological classification data. Acoustic doppler current profiler (ADCP) data is being used to understand the current dynamics within the entrance region of Glacier Bay and the influence of frontal zones on larval and plankton distribution and abundance. A 3-dimensional hydrodynamic model of Glacier Bay is also being developed in conjunction with this work. As part of a long-term fisheries marine ecosystem project, the effects of a fishing closure on the population of Dungeness crabs in Glacier Bay are being measured at sites where commercial fishing is closed and at the single site where commercial fishing continues. Movement of sonic tagged king and Tanner crabs relative to the reserve is being measured with an acoustic gate along its boundary. Relative population densities of Pacific halibut are also being estimated inside and outside the closed area.

**Satellite Remote Sensing:** The applicability of satellite remote sensing technologies for assessing linkages between climate, habitat conditions, and wildlife population dynamics are being investigated by USGS scientists on a number of fronts. One focus is the investigation of sea ice parameters in the Beaufort and Chukchi Seas relative to atmospheric circulation patterns and arctic marine mammals. Another focus is the distribution and quality of foraging habitats for the Porcupine caribou herd relative to climate variability in the Arctic National Wildlife Refuge.

**Restoration of Sagebrush Habitats in the Great Basin and Columbia Plateau:** Restoring sagebrush habitats in the sagebrush biome is a tremendous challenge. Low precipitation, fragile

soils, competition from exotic plants, and technological difficulties are barriers to success, and logistics and limited funding restrict the number of areas in which managers can attempt restoration. We are developing models using spatial data to assist in prioritizing regions in which success is most likely and of greatest benefit to greater sage-grouse and other wildlife. The models combine information about soils, precipitation, and other environmental features across the entire sagebrush biome, as well as information about locations of sage-grouse and sagebrush habitats.

**Coordinated Intermountain Restoration Program:** The Coordinated Intermountain Restoration Program provides research and technical assistance needed to understand the effects of disturbance and invasive plants on the structure and function of Wyoming sagebrush ecosystems and how to restore native plants on areas where cheatgrass dominates. The program promotes the understanding of disturbance dynamics, but at a more applied level, it also provides guidance with selecting plant materials, site preparation techniques, methods of weed control, seeding equipment, management methods, and monitoring techniques for restoration projects. A third facet is research and technical assistance associated with fuels management to reduce the impacts of wildfires on semi-arid rangeland ecosystems where exotic annual grasses provide the fuel. This is a major collaboration, involving USGS, the Bureau of Land Management, and many other partners.

**Ecological Conditions in the Sagebrush Biome:** The USGS is working in close partnership with other federal, state, university, and nongovernmental partners to conduct research that will improve our understanding of ecological conditions in the sagebrush biome and to provide information needed to manage and restore sagebrush ecosystems and the species that depend upon them. Specifically, the USGS is integrating its science disciplines to focus on four areas:

- Understanding the effects of habitat change on sagebrush-obligate species,
- Developing cost-effective methods for restoring functioning sagebrush ecosystem,
- Implementing quantitative monitoring strategies as part of an adaptive program to detect changes resulting from management actions or habitat disturbances,
- Managing spatial and nonspatial data to provide the information needed by researchers, resource specialists, managers, and the public

**National Oil and Gas Assessment:** Oil and natural gas resources have been developed in the sagebrush biome for over a century, but recently, exploration and development have increased dramatically because of high demand for energy resources. A requirement for predicting ecological consequences of development is knowledge of where developments have and will occur. USGS scientists conducted energy resource assessments of basins with petroleum and coalbed-methane production potential throughout the Rocky Mountain Region and used this assessment to describe areas of current and potential future developments. We also are conducting an ecological analysis of one basin – the Wyoming Basin – to estimate the amount of habitat influenced directly due to activities associated with energy developments. In addition, we are using geographic information systems and remote sensing to quantify the indirect effects that potentially result from increased presence of exotic plants and from additional predators that affect wildlife populations.

**Salt Ponds Restoration:** USGS is helping to answer key questions for the complex wetland restoration of 16,500 acres of salt evaporation ponds in San Francisco Bay, which requires balancing tidal wetland restoration with existing beneficial habitat. USGS is providing science support for the project by conducting monitoring surveys to document change and facilitate adaptive management. At some salt ponds, USGS scientists have measured water quality parameters, nutrient concentrations, primary productivity, zooplankton, macroinvertebrates, fish, and birds across a range of salinities to describe trophic communities. The scientists are also

monitoring for changes in bird usage during the restoration of San Francisco South Bay salt ponds.

**Dynamics of Sediment in a Watershed Ecosystem:** California Department of Fish and Game Fishery Restoration Program grant funding supports new research by USGS scientists to evaluate the effectiveness of road restoration and revegetation treatments within Redwood Creek watershed that were implemented to remediate the impacts of timber harvest and road construction activities on stream water quality. Mill Creek, a nearby watershed with past intense timber harvest, has recently been added to the California State Park system. A watershed restoration program at Redwood National and State Parks has been correcting erosion problems and revegetating previously logged hill slopes for over 20 years. This type of work is proposed for the newly acquired Mill Creek lands as well. USGS scientists, in cooperation with the CDFG, are now evaluating the effects of such rehabilitation work on stream channels. This study will assess the degree and rates of stream recovery following watershed restoration efforts. It will model various restoration scenarios to determine the most effective strategy for stream improvement.

**Disturbance Effects over Time on Resource Islands in Shrub-Woodlands:** Resource islands in ecosystems are the spaces under woody vegetation that have higher concentrations of soil nutrients, such as nitrogen, compared to sparsely vegetated spaces between the woody vegetation. The USGS and Oregon State University collaborated in describing how two disturbances—fire and removal by cutting—affect nitrogen in resource islands in basin-big sagebrush and bluebunch wheatgrass communities. The scientists studied four sites in central Oregon where western juniper was encroaching. Woody vegetation was burned or removed, and soil samples were taken from under the canopies (resource islands) and in the interspaces for 13 months. The authors found that nitrogen concentrations under the canopies were at least 1.4 times interspace concentrations and could be detected for up to a year after the canopy was removed. Burning in particular caused a significant increase in nitrogen that was detectable for about four months. This flush of nitrogen could favor the growth of exotic annual grasses, for example cheatgrass, especially if burns occur in the fall when these grasses are able to quickly take up available nitrogen.

**Establishing Bluebunch and Crested Wheatgrass Seedlings in Big Sagebrush Communities:** Restoration of sagebrush-grasslands in the West often includes complete removal of shrubs prior to seeding of introduced grasses, such as crested wheatgrass (*Agropyron desertorum*). We now recognize the importance of retaining some woody plants plus the use of native species during restoration. A recently published USGS study examined seeding native bluebunch wheatgrass (*Pseudoroegneria spicata*) and crested wheatgrass directly into stands of sagebrush at sites near Logan, Utah. The objective was to determine if survival and growth of these two grasses was affected by shading and root interference from sagebrush. The authors established four different shade treatments ranging from 90% shade to full sun. The study found that, on average, 75% of both species of grass seedlings survived. Strong shade reduced bluebunch wheatgrass survival early in the first growing season, and root interference with sagebrush reduced crested wheatgrass survival in all shade treatments. The authors suggested that bluebunch wheatgrass is as suitable for restoration as crested wheatgrass, and it should be seeded on the south sides of sagebrush in the transition zones between canopies undershrubs and the spaces between shrubs.

**Protocols for Monitoring Mountain Ponds and Lakes:** Sampling protocols for monitoring abiotic and biotic characteristics of mountain ponds and lakes are now available from the USGS. The protocols are the end result of a cooperative project between USGS and the North Coast and Cascades Network (NCCN) of the National Park Service. The project was one part of a larger effort by NCCN to identify ecosystem vital signs and develop sampling designs and protocols for the

long-term monitoring of the network's park ecosystems. The protocol contains standard operating procedures for sampling the physical, chemical and biological (including amphibians and fish) characteristics of mountain ponds and lakes, as well as procedures for data and database management. The protocols also describe how to select sites as part of a two-level sampling design for the assessment of the status and trends of pond and lake characteristics.

**Stream Network Pattern - New Frontier for Geospatial Analysis:** The branched structure of hydrologic drainages is a visible and fascinating example of network patterns on the landscape. Ecologists have recently begun to examine the spatial relationships between network structure and the distribution of plants and animals in stream ecosystems. However, the concepts of distance and connectedness in a stream network are complicated and require innovative statistical considerations and approaches to analysis that evaluate spatial pattern between points along a network as opposed to the shortest "as the crow flies" distance. In collaboration with Oregon State University, the USGS released information about a practical approach using commercially available software and geostatistics to explore spatial patterns of trout distribution in headwater stream networks. This work was done as part of the Cooperative Forest Ecosystem Research (CFER) Program. CFER is a consortium of federal and state partners.

**Native Amphibians, Nonnative Predators, and Landscape Change in Willamette Valley Wetlands, Oregon:** Wetlands have been dramatically altered throughout lowland in the western USA through direct loss and modification, as well as through introduction of a suite of nonnative predators. To improve wetland conservation and mitigation practices in the region, USGS scientists ranked factors that predict the presence of amphibian breeding in Willamette Valley wetlands. They analyzed wetland characteristics, presence of non-native aquatic predators, and landscape characteristics in a mixed urban-agricultural landscape. The absence of non-native fish was a strong predictor of occurrence for four out of the five native species. The two widest ranging species that use forests outside of breeding season (red-legged frog and roughskin newt) were more related to landscape variables than the other native species. The research found little evidence to support negative effects of the presence of breeding populations of bullfrog (*Rana catesbeiana*) on any of the native species, but this analysis was based on occurrence rather than abundance. Local wetland attributes outperformed landscape characteristics as predictors of native species occurrence. More broadly, the stressors that ranked as most important for native amphibian occurrence were consistent with those predicted by each native species life history. The authors recommend that amphibians will benefit from wetland preservation and mitigation efforts that concentrate on sites lacking non-native fish. Temporary wetlands that last into summer are also likely to be particularly important habitats for Willamette Valley amphibians.

**Grazing Research:** USGS scientists are involved with several projects examining the effects of grazing on wildlife and wildlife habitat. One study is documenting how areas that no longer support cattle grazing changed compared to areas that are still being grazed. Removal of livestock from the Escalante River watershed in the Grand Staircase-Escalante National Monument provides an opportunity to document how riparian and aquatic amphibians and invertebrates respond to elimination of grazing and trampling effects of livestock after decades of use. In addition, conceptual models are being developed from long-term monitoring efforts on the southern Colorado Plateau. This project deals extensively with effects of grazing on ecosystem attributes encompassed in the concept of rangeland health.

**Use of Molecular Tools for the Genetic Analyses of Endemic and Invasive Species and Disease Organisms in Hawaii and Pacific Island Trust Territories:** USGS scientists are applying

molecular methods to provide a better understanding of the genetic uniqueness of isolated populations of endemic and indigenous species across their current ranges; provide genetic information about invasive species and diseases and disease vectors that will assist in development of new strategies for their management and control; and to identify reductions in genetic diversity that have occurred following the introduction of invasive species and diseases and loss of suitable habitats.

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## **DROUGHT/CLIMATE CHANGE**

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**Hydro-Climatic Processes and Hazards:** Patterns displayed by climate forcings and hydrologic responses may be overlooked at a local scale and the co-variation of precipitation, temperature and other atmospheric conditions may not be evident until viewed from a regional spatial scale. The appraisal and management of the Nation's water resources requires the extraction of as much order and predictability from hydro-climate data as possible and thus requires a regional perspective. Temporal climate variations result from a wide range of physical, chemical, and biological processes, including chaotic or near-chaotic fluid dynamics, complex radiative and thermodynamic processes, tropical/extra-tropical interactions, ocean-air interactions, and the responses of terrestrial ecosystems to atmospheric influences. Understanding the Nation's hydro-climate, water resources, and water-related hazards requires improved understanding and integration of these processes and interactions into interpretations and procedures. The primary objectives of this project are to identify (1) climatologically induced relations within the Nation's hydrologic and water resources system, (2) recurring hydro-climatological patterns and climatologically imposed limits on hydrologic and water resources systems, (3) conditions leading to climatological extremes and resultant hydrologic hazards, and (4) regional and global climatic precursors of hydrologic events and hazards.

**Tropical and Arid Regions Climate:** This USGS project seeks to quantify past variations in climate and the hydrologic balance through studies of paleo and modern surface- and ground-water systems using stable isotope and other chemical methodologies. Objectives of the Tropical and Arid Regions Climate Projects are to determine: (1) the frequency and severity of drought during the past 10,000 years, (2) the frequency and severity of major cooling events that led to glacial advances in the Colorado Rockies, and (3) the frequency of hurricanes that impacted the Caribbean and Gulf of Mexico over the past 400 years

**Historical Perspective of Statewide Streamflows During the 1977 and 2002 Droughts in Colorado:** Since the late 1800's, Colorado has experienced several periods of drought that have varied from about 1 to 11 years in duration. The most recent statewide drought began during 1999 and extended into 2002, a year characterized by precipitation, snowpack accumulation, and streamflow much lower than normal. Statewide, mountain snowpack was about 53 percent of normal on April 1, 2002, the lowest since 1977, and accumulated precipitation during September, 2001-August, 2002, was the lowest on record for 9 of 15 long-term precipitation stations analyzed. The low snowpack and overall lack of precipitation resulted in very low streamflows throughout Colorado during 2002. A USGS analysis of streamflow and water-quality data obtained at 146 stations during 1978-2002 (after 1977, the last year of greatly diminished streamflows throughout Colorado) indicated that mean summer streamflows (July-September) during 2002 were the lowest on record during that 25-year period at 116 of the stations.

**"Live Fast, Die Young" Also Applies to Forests:** Trees in the world's most productive forests - forests that add the most new growth each year - also tend to die young, according to a USGS study. This discovery could help scientists predict how forests will respond to ongoing and future environmental changes. USGS scientists showed that birth and death rates of trees vary in parallel with global and regional patterns of forest productivity. Half of all trees in tropical forests growing on rich soils die and are replaced by new trees in just 30 years. In comparison, a century or more can pass before half of the trees die and are replaced in coniferous forests growing at high latitudes. Implications of fast turnover include: 1) the world's most productive forests may be those likely to respond most quickly to such things as climatic change, 2) environmental changes that increase productivity of a given forest could lead to more rapid turnover of trees (decreasing the average age of trees), and 3) increased dominance by younger trees could lead to changes in the amount of carbon stored in forests.

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## **HAZARDS**

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**Near Real-Time Streamflow Gaging Stations - a Tool for Flood Forecasting:** USGS scientists in the 15-state Central Region operate approximately 2,400 streamflow gaging stations. The majority of those stations have telemetry equipment that allows the stream stage and discharge to be displayed in near real-time on publicly available web pages. This information is used by the National Weather Service to monitor stream levels during times of potential and active flooding and is an important component of their flood forecasting capabilities. In addition, long-term historical streamflow data obtained from this network (in actuality a national network of approximately 7,000 active gaging stations) is invaluable in assessing potential hazards associated with floods and droughts based upon analysis of historical streamflow.

**Nitrogen Pollution:** USGS research results on invasive species and the fire cycle under nitrogen deposition indicate that in desert regions increased levels of soil nitrogen from atmospheric nitrogen deposition, or from other sources, could increase the dominance of alien annual plants, possibly promote the invasion of new species, and may increase the frequency and size of wildland fires through increased fuel loads from alien annual grasses.

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## **MISCELLANEOUS**

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**Coastal Protocols for Monitoring:** A long-term monitoring protocol is being developed by USGS biologists for the intertidal region at Sitka National Historical Park. Additionally, several process-oriented studies on intertidal community recovery (succession) from ice scour, the actions of an important predatory snail, and colonization and recruitment of invertebrates are being conducted to supplement intertidal monitoring in Glacier Bay National Park.

**Geomorphic Variables Critical to Stream Restoration in the Matanuska-Susitna Valley, Alaska:** USGS scientists are working closely with US Fish and Wildlife Service (USFWS) to

determine geomorphic variables most relevant to stream restoration in the Matanuska-Susitna valley, a rapidly developing area with a network of lakes and small streams. Strategic incorporation of geomorphic and hydrologic metrics into an examination of channels in environments ranging from peat bogs to steep mountain streams will guide USFWS oversight of restoration in the region. Sites on several relatively undisturbed streams are being surveyed in detail to establish a database of existing conditions and a structure for future measurements on these and other streams by USFWS.

**Integration of Sound Science and Adaptive Strategies in Sage Grouse Conservation Planning:**

USGS scientists recognize that getting science that is relevant to decision makers is not as easy as merely generating the data and providing access to these data. We continuously strive to bridge the gap between the information decision makers require and the information generated through research. Demonstrating this kind of support, the USGS is part of an effective collaboration with a local working group in Nevada and eastern California (the Bi-State Work Group) where we have helped develop a conservation plan for greater sage-grouse and have ongoing work developing. Ongoing work with this group and other partners includes development of models that integrate policy and economic choices, sage-grouse habitat maps, and plans for monitoring sage grouse populations

**Role of Information Portals and Data Management Systems:** Huge amounts of biological information are compiled about the sagebrush biome every year. Effective access to this information by management agencies, policy makers, the general public, and researchers is crucial. Consequently, the USGS and collaborating agencies invested heavily in the development of information portals. In 2001, the Bureau of Land Management and USGS launched a web portal, called SAGEMAP, designed to deliver spatial data and other information on sagebrush ecosystems to researchers and managers in a concise and easily searchable format. Other information portals that provide biological and spatial data for the sagebrush biome are the Great Basin Information Project, the Wildlife Disease Information Node, and the Mountain Prairie Information Node, all managed under the auspices of the National Biological Information Infrastructure. One aspect of the Great Basin Information Project is a science locator system, aimed at providing brief descriptions of all research in the Great Basin, cross referenced to locations where the research occurs and to the investigators involved.

**Internet Map Service for Environmental Health in the U.S.-Mexico Border Region:** In partnership with local, state, and federal agencies in both the United States and Mexico, the USGS has incorporated biologic, geologic, hydrologic, environmental, public health, and demographic datasets into a bi-national Internet Map Service (IMS). The objective of the project is to provide an earth and biological resources database within a geographic framework to further our understanding of the condition of the physical environment.

**The Southwest Information Node (SWIN):** This node of the USGS National Biological Information Infrastructure is being developed to provide access to hundreds of biological databases and to host a suite of information tools tailored to address the complex environmental issues of the Southwest. These tools will let users browse, model, map, simulate, forecast, interpret, and visualize biological and environmental conditions and processes. Current tools include a searchable database of scientific research and collection activities on federal public lands in New Mexico and Arizona; an interactive GIS mapper; a GIS-based decision support system addressing critical habitat for threatened and endangered species; and an index of water, drought, and fire-related datasets from state and federal agencies.

**Technical Assistance to USFWS on Comprehensive Conservation Planning at Refuges:** The USFWS is required by law to develop a Comprehensive Conservation Plan (CCP) for each unit of the National Wildlife Refuge System. USGS scientists continue to provide expertise to the USFWS in the development of scientifically sound CCPs. This assistance has included improving and teaching the biological and habitat portions of the national CCP course, and developing the technical and biological content of the Goal & Objective Handbook. Additionally, each CCP must contain an analysis of social and economic conditions and evaluate social and economic results from likely management scenarios. USGS social scientists assisting the USFWS (Regions 2, 5, and 6) by providing social science research that addresses visitor recreational experience and preferences, institutional and socioeconomic analyses, community profiles, and regional economic impact analyses for management alternatives.

**Assistance to USFWS National Elk Refuge Elk and Bison Management Plan:** USGS social scientists designed and conducted research to determine how the current and proposed management practices for bison and elk inhabiting the National Elk Refuge and Grand Teton National Park would affect stakeholder preferences, visitor use, visitor expenditures, local area employment and income, and visitor net economic benefits. Results were provided to the EIS Interagency Team on the Draft EIS Stakeholder Values and Perspectives and Socioeconomic sections. In addition, USGS scientists developed an institutional and economic framework that incorporates the institutional complexities and predicts stakeholders' influence and preferences for the bison and elk EIS decision-making process.

**Judgments of Responsibility for Wolf Encounters in the Southern Greater Yellowstone Area:** The continued growth of the wolf population in the Jackson-Hole Ecosystem presents managers with the challenge of balancing the biological needs of the species with public concerns, including human-wolf conflicts such as depredation of livestock. Attribution theory can help facilitate the understanding of how people form judgments of responsibility following a variety of conflict situations. A survey, "Public Perceptions of Wolf Management Actions in the Southern Greater Yellowstone Area," was developed by USGS scientists and distributed to 1320 residents within a 100 mile radius of Jackson, Wyoming, and to 748 visitors to Grand Teton National Park. The project measured these judgments of responsibility; acceptance and presumption of effectiveness of alternative management actions; public emotions in relation to wolves and wolf conflicts; and their personal and hypothetical experience with wolves. The successful application of attribution theory to a natural resource management issue helped demonstrate the utility of this line of research for managers in dealing with and understanding the affected public. Knowledge of how stakeholders form judgments of responsibility following negative encounters with wolves, and their concomitant emotions and judgments concerning management actions, can assist agency managers in choosing and implementing actions needed to remedy such situations. This also gives managers some reasonable expectations of the kind of public reaction they can anticipate, depending on their management choices.