

US Geological Survey Amphibian Research and Monitoring Initiative Rocky Mountain Region, 2006 Progress Report

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Amphibian monitoring and research in the Rocky Mountains is conducted through two Science Centers. The Northern Rocky Mountain Science Center, Aldo Leopold Wilderness Research Institute in Missoula, Montana and partners, including faculty and graduate students at Idaho State University and the University of Montana, conduct studies in the northern part of the region. The Leopold Institute is an interagency center, hosted by the US Forest Service, with the mission to develop the knowledge needed to improve management of wilderness and other natural areas. Why conduct amphibian research at a research center devoted to wilderness? Although amphibian diversity in western wilderness is typically low, amphibians occupy important ecological niches, and declines have been excessively severe in the western U.S. This includes designated wilderness and backcountry areas of National Parks, which are generally considered to be refuges for protecting species. In the south, the Fort Collins Science Center (FORT) is located on the Natural Resources Research Campus (NRRC) at Colorado State University in Fort Collins, Colorado. The NRRC is a partnership of six federal agencies and CSU and was established to support and enhance cooperative research on natural resource issues.

ARMI monitoring projects in the Rocky Mountains include base-level inventories, mid-level long-term monitoring, and intensive population studies at Apex sites (Table 1). The Great Divide transect, distributed over 8° of latitude, with gradients of climate, development, and status of amphibian populations (Corn et al. 2005), comprises Glacier, Yellowstone, Grand Teton (collectively the Greater Yellowstone Ecosystem, or GYE), and Rocky Mountain National Parks,. Studies in Yellowstone and Grand Teton were funded in 2006 by the National Park Service Greater Yellowstone Inventory and Monitoring Network (GRYN) to Chuck Peterson at Idaho State University. Inventories include a collaborative effort on National Forests and Department of Interior lands in Montana, conducted by Bryce Maxell at the Montana Natural Heritage Program, and funded in 2005 for 3 years through the ARMI competitive grants program.

We implemented a subtle shift in the study design for mid-level monitoring in 2005 and 2006. Previous efforts analyzed occupancy rates of each species at individual wetland sites in relatively large watersheds. However, the small number of large watersheds that can be sampled with the resources available made obtaining a representative sample in the GYE impossible. Also, analyzing occupancy at the wetland level potentially ignores population processes and may result in greater variation that can hinder detection of significant changes in abundance. To address these problems, we reduced watershed size and selected a larger number to sample. We will continue to analyze occupancy at the site level, but we will also estimate occupancy at the watershed (or catchment) level, with the expectation that there will be less year-to-year variation and a greater ability to detect changes at the landscape level. This new design used new GIS layers created at USGS-EROS.

Table 1. Current monitoring locations in the Rocky Mountain region. See previous reports for complete listing of study locations.

Location	State	Agency/Collaborator	Period	Primary Species
Apex Monitoring Sites				
Lost Trail NWR, Dahl Lake & several ponds	MT	USFWS	2003 – ongoing	<i>Bufo boreas</i>
Lubrecht Experimental Forest, Jones Pond	MT	Univ Montana	2004 – ongoing	<i>B. boreas</i>
Glacier National Park, three catchments	MT	National Park Service	1999 – ongoing	<i>B. boreas</i>
Bitterroot National Forest, Lost Horse Marsh	MT	US Forest Service	1999 – ongoing	<i>Rana luteiventris</i>
Bitterroot National Forest, Selway-Bitterroot Wilderness, Little Rock Creek Basin	MT	US Forest Service/ Montana Heritage Program	2001 – ongoing	<i>R. luteiventris</i>
Yellowstone National Park, Lodge Creek	WY	National Park Service/Idaho State Univ	(1953 –1955) 1992 – ongoing	<i>R. luteiventris</i>
Bridger-Teton National Forest, Black Rock Ranger Station	WY	US Forest Service/Idaho State Univ	2003 – ongoing	<i>B. boreas</i>
National Elk Refuge, Nowlin Creek & Romney Pond	WY	USFWS/Idaho State Univ	1998 – ongoing	<i>B. boreas</i>
Arapaho-Roosevelt National Forest, Lily & Matthews ponds	CO	US Forest Service	(1961 – 1973) 1986 – ongoing	<i>Pseudacris maculata</i>
Rocky Mountain National Park, North Fork Big Thompson River, Spruce Lake	CO	National Park Service	1991 – ongoing	<i>B. boreas</i>
Rocky Mountain National Park, Kawuneeche Valley	CO	National Park Service/Colorado State Univ	2002 – ongoing	<i>Rana sylvatica</i>
San Isabel National Forest, Collegiate Peaks Wilderness, Denny Creek	CO	US Forest Service/Colorado Division of Wildlife	Ongoing	<i>B. boreas</i>
Mid-level Monitoring Sites				
Glacier National Park	MT	National Park Service	1999 – ongoing	<i>Ambystoma macrodactylum</i> , <i>A. montanus</i> , <i>B. boreas</i> , <i>R. luteiventris</i>
GYE (Yellowstone & Grand Teton national parks, JD Rockefeller Parkway)	MT, WY	National Park Service/Idaho State Univ	2000 – ongoing	<i>Ambystoma tigrinum</i> , <i>B. boreas</i> , <i>P. maculata</i> , <i>R. luteiventris</i>
Rocky Mountain National Park	CO	National Park Service	1988 – 1990, 1994, 2000 – ongoing	<i>A. tigrinum</i> , <i>B. boreas</i> , <i>P. maculata</i> , <i>R. sylvatica</i>
Theodore Roosevelt National Park	ND	National Park Service	2001 – 2002, 2006	<i>A. tigrinum</i> , <i>Bufo cognatus</i> , <i>Bufo woodhousii</i> , <i>P. maculata</i> , <i>Rana pipiens</i> , <i>Spea bombifrons</i>
Base level Inventories				
National Forests and BLM lands in Montana	MT	US Forest Service, Bureau of Land Management/Montana Heritage Program	2001 – ongoing	Inventories target all species at a location

Research projects in the Rocky Mountain region in 2006 include a study funded competitively through the Park Oriented Biological Support Program to Corn and Sophie St.-Hilaire (Idaho State University) to determine the prevalence of chytrid fungus in Grand Teton National Park and the comparable pathogenicity of locally-cultured strains of the fungus to boreal toads. Several studies concluded field work in 2005 and 2006, including ARMI funded studies on effects of wildfire on amphibians in Glacier National Park (enhanced and expanded with additional Forest Service funding to the University of Montana), and establishing distribution of chytrid fungus in the Rocky Mountains and evaluating threats to boreal toads. A Joint Fire Sciences Program study begun in 2002 uses an ecosystem approach to study the effects of prescribed and wildland fires on stream ecosystems by monitoring amphibians, invertebrates, periphyton, and aquatic habitat conditions. This study received additional JFSP support in 2005 and completed field work in 2006. Two graduate student projects at Montana and one at CSU are in progress. Topics include population biology of Columbia spotted frogs, effects of wildfire on habitat use by boreal toads, and the effects of fragmentation and loss of habitat for wood frogs driven by changing water regimes in protected areas. The Idaho State University Herpetology Laboratory is collaborating with the USGS Eros Data Center and Montana State University to develop wetland and amphibian habitat models for Yellowstone National Park.

2006 Progress and Results

Mid-level Monitoring—At the south end of the Great Divide Transect, a field crew surveyed 117 sites in 14 randomly selected catchments in Rocky Mountain National Park. An additional 285 surveys were conducted at 95 sites in the Kawuneeche Valley on the west side of the park, selected based on historic records rather than randomly. In the GYE four field crews surveyed 261 wetlands in 32 catchments, including 199 wetlands in 25 catchments in YELL and 62 wetlands in 7 catchments in GRTE. We surveyed 165 wetlands in 19 catchments in Glacier National Park with two field crews.

Naïve and estimated occupancies in 2006 continue to reflect a trend of decreasing occupancy from north to south (Table 2). As expected, catchment occupancy is higher than wetland occupancy and probably provides the best method for tracking trends of uncommon species, such as boreal toads. Amphibians are so scarce in Rocky Mountain National Park that two species did not

Table 2. Individual wetland and small catchment naïve and estimated ($\hat{\Psi}$) occupancies (bootstrapped standard errors) in 2006.

Species	Catchments			Wetlands		
	Naïve	\hat{p}	$\hat{\Psi}$	Naïve	\hat{p}	$\hat{\Psi}$
Glacier National Park			(19)			(165)
<i>Ambystoma macrodactylum</i>	0.74	0.96	0.74 (0.10)	0.59	0.90	0.60 (0.04)
<i>Bufo boreas</i>	0.32	0.91	0.32 (0.11)	0.06	0.88	0.06 (0.02)
<i>Rana luteiventris</i>	0.68	0.92	0.69 (0.11)	0.23	0.88	0.23 (0.03)
Greater Yellowstone Ecosystem			(32)			(261)
<i>A. tigrinum</i>	0.26	0.88	0.29 (0.08)	0.06	0.85	0.07 (0.02)
<i>B. boreas</i>	0.15	0.75	0.17 (0.16)	0.03	0.86	0.03 (0.03)
<i>Pseudacris maculata</i>	0.59	0.97	0.60 (0.08)	0.28	0.93	0.32 (0.03)
<i>R. luteiventris</i>	0.68	0.96	0.72 (0.08)	0.18	0.84	0.22 (0.03)
Rocky Mountain National Park			(14)			(117)
<i>A. tigrinum</i>	0.07	1.0	0.07 (0.07)	0.02	0.87	0.02 (0.01)
<i>B. boreas</i>	–			–		
<i>P. maculata</i>	0.29	0.93	0.29 (0.12)	0.12	0.62	0.13 (0.03)
<i>R. sylvatica</i>	–			–		

register in 2006. For wood frogs, the selected catchments generally lie outside the distribution of the species, perhaps necessitating some adjustment of catchments to be sampled.

Inventories—Since 2004, we have been shifting to a greater emphasis on the mid-level monitoring. Inventories are currently represented by the cooperative agreement with the Montana Natural Heritage Program. To date, 349 watersheds (6th-code HUCs) and more than 5600 water bodies have been surveyed. This has resulted in over 6200 species records with numerous extensions of known geographic ranges and maximum elevations. Boreal toads have been found breeding at only 1–3% of sites surveyed.

Apex sites—2005 featured a return of boreal toads to Lost Trail NWR in Montana. We observed only 9 toads in 2004, after having marked 358 individual adults in 2003. In 2005, 247 adult toads were captured, including 19 marked previously. In 2006, 422 adult toads were captured, including 43 marked previously and 379 newly marked animals. At the Lubrecht Experimental Forest, 38 individual toads were marked, down from the 114 and 94 marked in 2004 and 2005, respectively. At Black Rock in Wyoming, we marked 146 new adult toads and recaptured 103 adult toads in 2006, less than in previous years, but the level of effort was less in 2006. This population and the population of toads at Lost Trail NWR continue to be the largest known in Wyoming and Montana. Occupancy of toads in selected watersheds in Glacier was similar to levels found in previous years. Mid-level monitoring for boreal toads in the GYE is supplemented by visits to previously identified breeding areas. We have found 42 toad breeding areas and visited 32 of these in 2006, with more intensive monitoring conducted on the National Elk Refuge. Evidence of breeding (eggs, tadpoles, or recent metamorphs) was found at 24 areas, or 75% occupancy. Most of the absences occurred at sites where toad larvae were previously observed rarely or intermittently over the past decade. There is no indication that toad populations are disappearing from major, consistently-used breeding sites despite the high prevalence of chytrid that has been discovered by research projects. We continue to monitor boreal toads in Rocky Mountain National Park. At Kettle Tarn, the site of a formerly robust boreal toad population, we found 3 unmarked females and one dead male (Bd testing pending [NWHC, David Green]). One egg mass was located, but did not produce larvae because the water level dropped in the pond. Spruce Lake has been monitored for the last 6 years: preliminary analysis suggests that the population is very small (about 26 individuals). The Spruce Lake site has tested positive for presence of Bd by swabbing and also by the preliminary environmental test (Kirschtein, Anderson, Voytek, Wood and Longcore, in prep.).

Boreal chorus frogs were monitored for the 21st consecutive year at 2 sites in northern Colorado using capture-recapture and automated frog call recorders.

Dissertation research by Bryce Maxell from 2001 to 2004 in the Selway-Bitterroot Wilderness, Montana included more than 30,000 captures of at least 12,000 individual Columbia Spotted frogs in 3 study basins. In 2005–6, Rebecca Wahl continued monitoring in Little Rock Creek as part of her dissertation research and in agreement with the Montana Natural Heritage Program.

Research— The POBS-funded chytrid study by Sophie St.-Hilaire, Peter Murphy, Charles Peterson, and Sarah Bruer (MS student) at Idaho State University was able to culture Bd from boreal toads at Black Rock, Wyoming. Initial laboratory investigations indicate Bd isolated from Wyoming and Colorado is pathogenic in high concentrations to recently metamorphosed boreal toads from Black Rock and a captive breeding facility in Colorado. Experiments are underway to determine what environmental conditions are necessary to result in mortality associated with this fungal agent.

Initial studies of the effects of wildfire on amphibians in Glacier National Park are largely complete. A paper describing effects on tailed frogs was published in *Canadian Journal of Zoology*, and a paper describing effects of the 2001 Moose fire on pond-breeding species is currently in press in *Ecological Applications*. Another paper describing the effects of the Moose Fire on the

chemistry and temperature of wetlands is in the USGS review process and will be submitted to the journal *Wetlands*. Wildfires continue to burn relatively large areas in Glacier, creating additional opportunities for research.

The JFSP-funded project headed by David Pilliod sampled 10 tributaries of the South Fork Salmon River in 2006. Two watersheds were burned with broadcast prescribed fire in May 2004 and a third was burned similarly in May 2006. We are currently processing macroinvertebrate samples and analyzing preliminary results of this BACI design. Unfortunately, the 2006 sampling season was interrupted by lightning-caused wildland fires that burned large portions of our study area, particularly in control streams. This has complicated our analysis, but also created opportunities. The final report for this project will be released in two volumes: *Wildland Fire Effects* will be available in January 2007 and *Prescribed Fire Effects* will be available in May 2007.

Dissertation research in Rocky Mountain National Park by Rick Scherer will provide managers with baseline data to monitor the wood frog and boreal chorus frog populations into the future and to facilitate a better understanding of the biotic and abiotic factors that affect the spatial distribution and dynamics of these species in the Kawuneeche Valley on the west side of the park. This project focuses on occupancy estimates for anurans and an evaluation of the role of pond- and landscape-scale variables in explaining variation in occupancy. As an adjunct to this dissertation research, the genetic spatial structure of wood frogs in the Kawuneeche Valley is being assessed. The purpose of this portion of the research is to identify attributes of the landscape that may be acting as barriers to gene flow by investigating patterns of genetic variation.

Plans for 2007

We expect to continue mid-level monitoring throughout the Great Divide transect; the GRYN will continue to contribute funding to Idaho State University for this effort. Given the continued attrition to the purchasing power of ARMI funding, the long-term success of this effort will require additional funds. We intend to continue to collect population data at the apex sites listed in Table 1, but funding constraints may also affect these efforts and prioritization will likely be necessary in the future. Field work by Rick Scherer on wood frogs will conclude. Inventories by the Montana Natural Heritage Program will continue.

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Reimbursable and Leveraged Funding

Collaborators in the Rocky Mountain Region have been highly successful in developing projects that interact with ARMI by sharing data, or which have similar objectives and make use of methods developed by ARMI, or collaborate in studying causes of amphibian declines. Total reimbursable and leveraged funding received in FY2006 totaled about \$231,000, or 90% of the USGS funding to the Rocky Mountain Region. Individual collaborative projects are listed below.

Recipient/Cooperator	Funding Source	Amount	Reimbursable (R) or Leveraged (L)	Project
Stephen Corn (NRMSC)/ Sophie St. Hilaire (Idaho State Univ)	Park Oriented Biological Support (NPS/USGS)	\$42,000	R	Assessing the Distribution and Effects of Chytrid Fungus on Amphibians in Grand Teton National Park
Bryce Maxell (Montana Natural Heritage Program)	ARMI	\$24,742	R	Amphibian & reptile inventories in Montana
Bryce Maxell (Montana Natural Heritage Program)	Montana Department of Fish, Wildlife & Parks; US Forest Service; Montana Department of Environmental Quality	\$126,000	L	Amphibian & reptile inventories in Montana
Chuck Peterson, Debra Patla (Idaho State University)	National Park Service, Greater Yellowstone I&M Network	\$38,000	L	Evaluation of amphibians for vital signs monitoring in the GRYN, boreal toad monitoring on the NER
Rebecca Wahl and Dalit Ucitel (University of Montana)	Five Valleys Audubon Society	\$495	L	Monitoring boreal toads at Lost Trail NWR

Products

Papers published in 2006

Dreitz VJ. 2006. Issues in species recovery: An example based on the Wyoming toad. *BioScience* 56:765–771.

Hossack BR. 2006. Amphibians and wildfire in the U.S. Northwest. *International Journal of Wilderness* 12:26, 43.

Hossack BR. 2006. *Rana luteiventris*: reproduction. *Herpetological Review* 37: 208–209.

Hossack BR, Diamond SA, Corn PS. 2006. Distribution of the boreal toad populations in relation to estimated UV-B dose in Glacier National Park, Montana, USA. *Canadian Journal of Zoology* 84:98–107.

Hossack BR, Corn PS, Fagre DB. 2006. Divergent patterns of abundance and age-class structure of head-water stream tadpoles in burned and unburned watersheds. *Canadian Journal of Zoology* 84:1482–1488.

Karraker NE, Pilliod DS, Adams MJ, Bull EL, Corn PS, Diller LV, Dupuis LA, Hayes MP, Hossack BR, Hodgson GR, Hyde EJ, Lohman K, Norman BR, Ollivier LM, Pearl CA, Peterson CR. 2006. Taxonomic and geographic variation in oviposition by tailed frogs (*Ascaphus* spp.). *Northwestern Naturalist* 87:87–97.

Muths E, Gallant AL, Grant EHC, Battaglin WA, Green DE, Staiger J, Walls, Gunzburger MS, Kearney R. 2006. The amphibian research and monitoring initiative (ARMI): 5-year report. U.S. Geological Survey Scientific Investigations Report 2006-5224. 75 p.

Muths E, Scherer RD, Corn PS, Lambert BR. 2006. Estimation of the probability of male toads to return to the breeding site. *Ecology* 87:1048–1056.

Scherer RD, Muths E, Noon BR, Corn PS. 2005. An evaluation of weather and disease as causes of decline in two populations of boreal toads. *Ecological Applications* 15:2150–2160.

Papers in press

Hossack BR, Corn PS. 2007. Responses of pond-breeding amphibians to wildfire: short-term patterns in occupancy and colonization. *Ecological Applications* 17: in press.

Presentations & Posters

February 2006 [Invited] – S. Corn. Current and Future Threats to Amphibian Populations. 2nd Alaska Amphibian Conference, Juneau.

March 2006 – S. Corn. The U.S. Geological Survey's Amphibian Research And Monitoring Initiative. Northwest Science Association/ Idaho Chapter of The Wildlife Society, Boise.

March 2006 – B. Hossack & S. Corn. Species-specific responses of amphibians to wildfire in Glacier National Park. Northwest Science Association/ Idaho Chapter of The Wildlife Society, Boise.

March 2006 [Invited] – E. Muths. The Amphibian Research and Monitoring Initiative: Grass roots to Nation-wide. Lyceum Evening Programs, Rocky Mountain National Park.

May 2006 [Invited] C.R. Peterson, R. Klaver, D. Pilliod, P. Bartelt, C. Jenkins, S. Spear and J. Shive Analyzing amphibian and reptile movements: diverse objectives and approaches. Home Range and Animal Movements: A Workshop. Idaho State University, Pocatello, Idaho.

July 2006 – E. Muths and V. Dreitz. Monitoring reintroductions: providing defensible data. Joint Meeting of Ichthyologists and Herpetologists, New Orleans, Louisiana.

September 2006 [Invited] – S. Corn, Climate Change and Amphibians. MTNCLIM 2006, Annual meeting of the Consortium for Integrated Climate Research on Western Mountains, Mt. Hood, Oregon.

September 2006 [Invited] S. St-Hilaire, P. Murphy, S. Bruer, P. Sheridan, D. Patla, and C. Peterson. Chytrid fungus in Grand Teton National Park. 2006 Resource Information Exchange Grand Teton National Park.

September 2006 [Invited] C. R. Peterson and D.A. Patla. Amphibian Monitoring in Grand Teton National Park. 2006 Resource Information Exchange Grand Teton National Park.