Northern Rocky Mountain Science Center
U.S. Department of the Interior
Geological Survey

ARMI Studies Examine Causes of Amphibian Decline In Rocky Mountain West

Background:

Amphibians and reptiles may provide insights into general ecosystem health due to their close association with various habitats and sensitivity to different dramatic changes in the environment, known as stressors. Habitat destruction and alteration have been shown to cause amphibian declines, but other stressors also may be contributing, including contaminants, introduced species, climate change, disease, or a variety of these and other factors acting in combination.

Columbia spotted frog (Rana luteiventris), Glacier National Park.

In response to the phenomenon of declining amphibian populations, the U.S. Geological Survey (USGS) established the Amphibian Research and Monitoring Initiative (ARMI) under the Wildlife and Terrestrial Resources Program. The objectives of ARMI are to:

- Monitor amphibian populations to understand the severity and scope of declines and malformations.
- Determine the causes of amphibian declines.
- Develop effective management actions to halt or reverse.
- Encourage collaboration by making the information available to cooperators, land managers, the scientific community, and

Study Area:

ARMI conducts long-term monitoring of amphibian populations at large study areas, including national parks, where the area of inference is well defined and sample locations are chosen in a probabilistic design.

At the USGS Northern Rocky Mountain Science Center (NOROCK) scientists and their collaborators at USGS Fort Collins Science Center, Idaho State University, and the NPS Greater Yellowstone Inventory and Monitoring Network, conduct monitoring in the national parks on the Continental Divide (Figure 1).

This transect comprises Glacier, Yellowstone, Grand Teton, and Rocky Mountain national parks. The parks differ in climate, vegetation, and amounts of human influence. Amphibian occupancy is higher in the north (Glacier NP)

Figure 1. Amphibian Research and Monitoring Initiative (ARMI) study area in the western U.S.

Projects:

In addition to monitoring amphibian occupancy on the Continental Divide, scientists at NOROCK collect more intensive data on individual populations of boreal toads and Columbia spotted frogs at several other locations in the Rocky Mountains, and conduct research into factors that may contribute to amphibian decline. Current emphasis is in the areas of disease, fire, and climate change.

Disease

Researchers at NOROCK are interested in the distribution and effects on amphibians of the pathogenic fungus *Batrachochytrium dendrobatidis*, commonly referred to as the amphibian chytrid fungus, or Bd, which infects the frog's skin and may cause problems in respiration or other effects, and is suspected as a leading cause of global amphibian declines.

NOROCK scientists have included Bd sampling in Glacier National Park and elsewhere in the northern Rockies as part of several studies. Routine sampling has revealed that Bd is commonly found on amphibians throughout the Rocky Mountains, but in the northern Rockies high levels of occurrence are not associated with die-offs of amphibi-

Current research include a new ARMI-funded study, with cooperators at the University of Montana and Virginia Commonwealth University, that examines the sub-lethal effects of fire on amphibians, and an on-going collaboration with the Fish and Wildlife Service to sample waterfowl as potential carriers of Bd between wetlands.

A recently-completed study surveyed habitats without amphibians, and failed to detect Bd at these sites. Two Bd studies funded through the Park-Oriented Biological Support (POBS) program are in collaboration with researchers at Idaho State University. The first of these, conducted in 2006-2007 found Bd to be widespread in and near Grand Teton National Park, and compared pathogenicities of Bd strains from Wyoming and Colorado on boreal toads from both locations. This study found that Bd found in Wyoming is as pathogenic as Bd from Colorado, but that behavioral responses of juvenile toads could reduce mortality in the laboratory. The second POBS study, new in 2008, is using radio telemetry to compare behavior of toads in Wyoming and Colorado relative to infection by Bd.

NOROCK scientist Blake Hossack demonstrates swabbing the skin of a boreal toad to detect the amphibian chytrid fungus, to the Conservation Ecology class from the University of Montana.

Fire

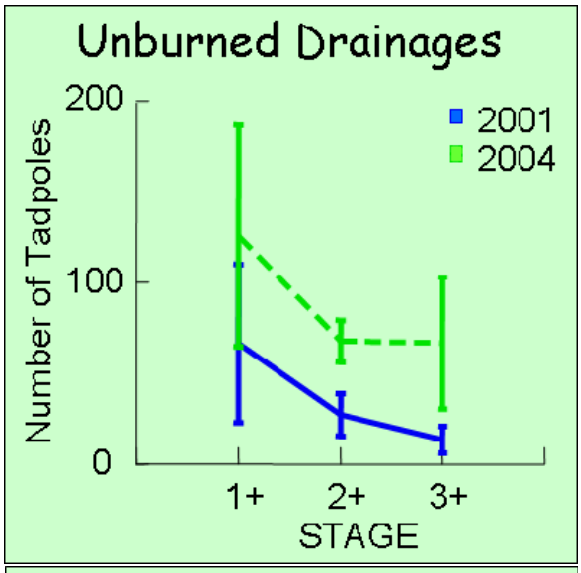
Researchers are examining the effects of wildfire and prescribed fire on amphibians, including studies funded by ARMI and the multi-agency Joint Fire Sciences Program (JFSP). Some of this work has taken advantage of wildfires in Glacier National Park that burned landscapes where considerable data on amphibian occurrence were already available, creating the opportunity for a ready made before after comparison.

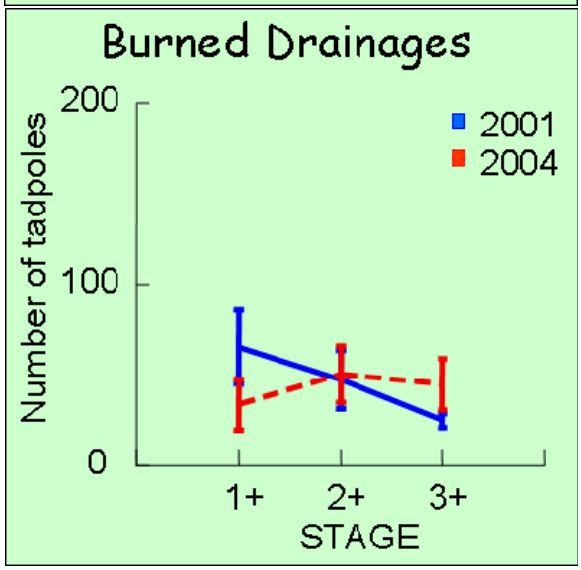
Studies have included both headwater streams and the Rocky Mountain tailed frog, and small wetlands and the species that breed in them. The primary negative effect of wildfire found so far was a reduction in 1st year tailed frog tadpoles in streams in burned areas, compared to unburned streams. This mirrors results from the JFSP study in western Montana and central Idaho.

Long-toed salamander (Ambystoma macrodactylum), Lost Trail NWR, Montana.

In contrast, in the small forested wetlands on the west side of Glacier National Park, there was no difference in occupancy of breeding sites before and after fire by long toed salamanders or Columbia spotted frogs. The number of breeding sites of boreal toads actually increased in burned areas, but the effect has proven to be temporary. Adult boreal toads equipped with radio transmitters showed a preference to use severely burned areas in the year after fire.

The new ARMI study on sub-lethal effects of fire is using Rocky Mountain tailed frogs and long-toed salamanders to compare unburned habitats to burned sites and burned sites that have been salvage logged. Responses will be assessed by comparing body condition, reproductive performance, and levels of stress-related hormones, in addition to sampling for Bd.





	Total Tadpoles	
	Unburned	*Burned*
2001	429	522
2004	1041	517

Figure 2. Effects of wildfire on Rocky Mountain Tailed frogs in 8 streams in and near Glacier National Park. Total numbers of tailed frog tadpoles did not decrease in burned streams, but did not show the large increases found in unburned streams between 2001 and 2004. The major effect appears to have been a reduction in the proportion of the smallest size/age class in burned streams (Hossack and Corn 2006).

Climate Change

Climate change and its effects on amphibians has long been an emphasis of NOROCK scientists. Considerable work has been devoted to the study of the effects of ultraviolet (UV) radiation on the distribution of amphibians in Glacier National Park, as part of a larger study of amphibians and UV in national parks across the country that included cooperators at the NPS, EPA, USGS Forest and Rangeland Ecosystem Science Center, University of California, and University of Arizona. This study found little relationship between UV and occurrence of amphibians at Glacier or other western parks, and that significant UV did not penetrate deeply into most amphibian habitats.

Another study, in collaboration with the Fort Collins Science Center used long-term observations of boreal chorus frogs in Colorado to demonstrate that potential UV exposure was related to phenology (timing of breeding) and that phenology of amphibians in western mountains is largely dependent on the timing of snowmelt. This observation is significant because mountain snowpacks are predicted to shrink drastically in extent and duration in coming years under most climate change scenarios. This has lead to a collaboration with several other herpetologists to use long term observations of breeding behavior and snow data to infer changes in phenology during the last 50 years and to predict changes during the coming decades.

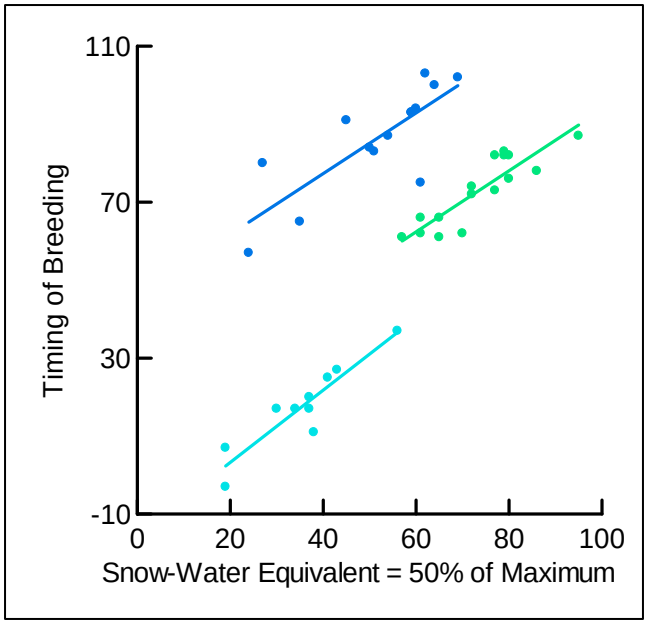


Figure 3. Timing of breeding versus timing of snowmelt (both expressed as the number of days from the Vernal Equinox) for 3 different amphibian species in 3 different mountain ranges in the West. Although the timing differs, all show the same relation between breeding and snowmelt (Corn, 2008).

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Boreal toad (Bufo boreas) mating ball, Bridger-Teton National Forest, Wyoming.

Selected Recent Publications:

Results of amphibian studies are communicated both through presentations to other scientists and land managers and publication in the primary scientific literature. Some recent papers include:

Corn PS, Muths E. 2002. Variable breeding phenology affects the exposure of amphibian embryos to ultraviolet radiation. **Ecology** 83:2958B2963.

Corn PS. 2003. Amphibian breeding and climate change: the importance of snow in the mountains. **Conservation Biology** 17:622B625.

Muths E, Corn PS, Pessier AP, Green DE. 2003. Evidence for disease□related amphibian decline in Colorado. **Biological Conservation** 110:357B365.

Adams MJ, Hossack, BR, Knapp RA, Corn PS, Diamond SA, Trenham PC, Fagre D. 2005. Distribution patterns of lentic□breeding amphibians in relation to ultraviolet radiation exposure in western North America. **Ecosystems** 8:488–500.

Corn PS, Hossack BR, Muths E, Patla DA, Peterson CR, Gallant AL. 2005. Status of amphibians on the Continental Divide: surveys on a transect from Montana to Colorado, USA. **Alytes** 22:85–94.

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

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.

Corn PS. 2007. Amphibians and disease: implications for conservation in the Greater Yellowstone Ecosystem. **Yellowstone Science** 15(2):11–16.

Hossack BR, Corn PS. 2007. Responses of pond-breeding amphibians to wildfire: short-term patterns in occupancy and colonization. **Ecological Applications** 17:1403–1410.

Guscio CG, Hossack BR, Eby LA, Corn PS. 2008. Post-breeding habitat use by adult boreal toads (*Bufo boreas boreas*) after wildfire in Glacier National Park, USA. **Herpetological Conservation and Biology** 3:55-–62.

Hossack BR, Corn PS. 2008. Wildland fire and seasonal wetlands: effects on water temperature and selection of breeding sites by the boreal toad (*Bufo boreas*). **Herpetological Conservation and Biology** 3:46–54.

Murphy PJ, St-Hilaire S, Bruer S, Peterson CR, Corn PS. In press. Distribution and pathogenicity of *Batrachochytrium dendrobatidis* in boreal toads from the Grand Teton area of western Wyoming. **EcoHealth**.