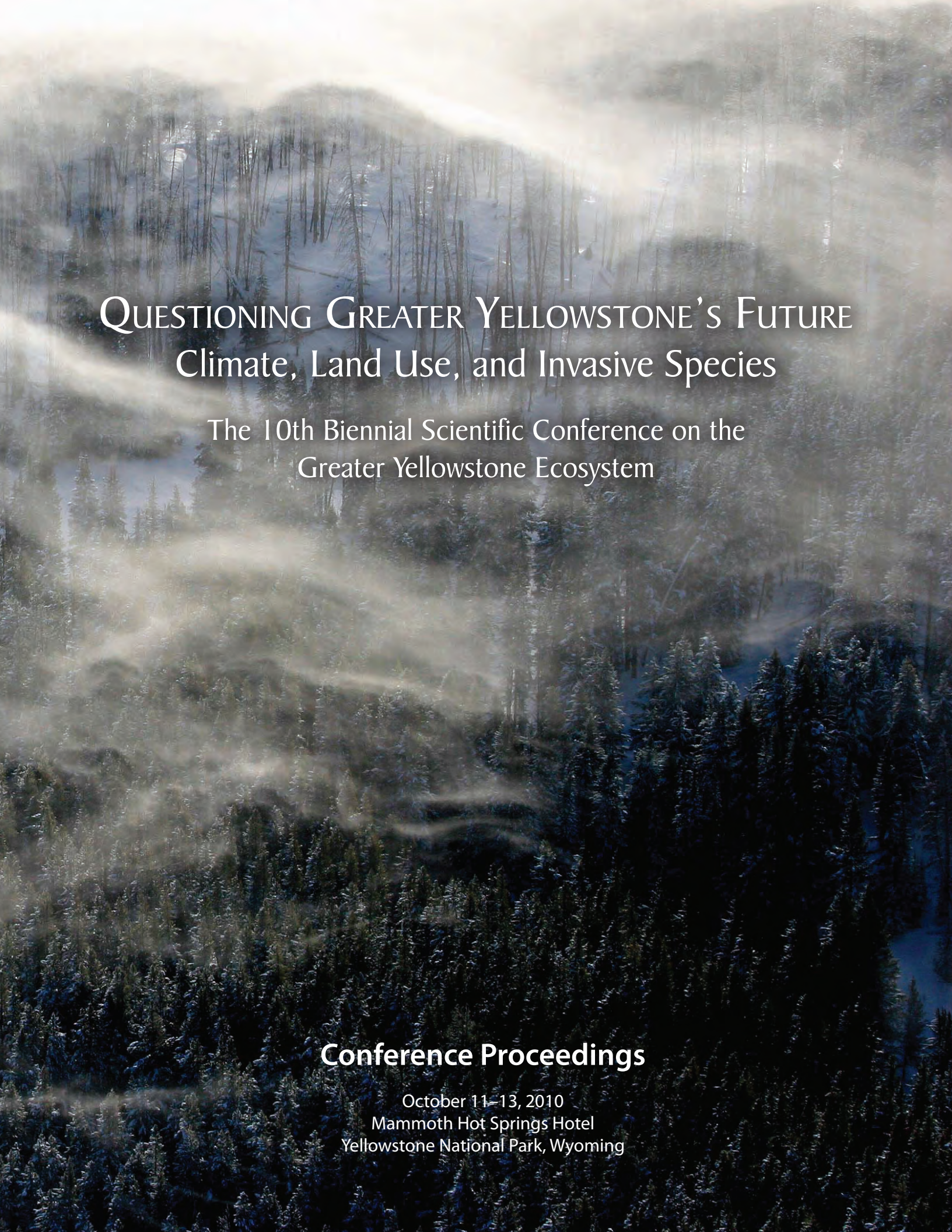

Questioning Greater Yellowstone's Future
Climate, Land Use, and Invasive Species

The 10th Biennial Scientific Conference on the Greater Yellowstone Ecosystem

Conference Proceedings

October 11–13, 2010
Mammoth Hot Springs Hotel
Yellowstone National Park, Wyoming

Questioning Greater Yellowstone's Future
Climate, Land Use, and Invasive Species

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Greater Yellowstone Ecosystem

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October 11–13, 2010
Mammoth Hot Springs Hotel
Yellowstone National Park, Wyoming

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with editing assistance from Anne Jakle and Emily Yost
and design assistance from Tana Stith

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Cover: Winter in the Pelican Valley, Yellowstone National Park, 2005. NPS/Dan Stahler.

Conference Mission

The mission of this conference was to generate discussion on changes in three external drivers—climate, land use, and invasive species—that could dramatically alter Greater Yellowstone's public and private lands. This conference offered participants an opportunity to help shape this region's future regarding key issues such as:

- How is the Greater Yellowstone climate likely to change in the near future and how do climate projections compare with historical patterns?
- What ecological changes are underway as a result of changing climate and land use, and what will be the consequences for human and natural systems?
- In what ways do increasing demands on public and private lands threaten a sustainable future?
- Which non-native species pose the greatest threat for the region and what are some of the anticipated environmental, social, economic, and human-health consequences of invasive species?
- What new administrative, technological, and scientific tools and strategies are required to address the challenges of changing climate and land use and the threats from invasive species?

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Foreword

"If Yellowstone's historical record can shed light on the current situation [of science and management], one ray of hope shining from the past might be that Yellowstone has a capacity for infecting its public with a curiosity for science and scientific endeavors, a love and respect for tradition, and with a sense of social responsibility to protect and preserve this place."

— Judith L. Meyer, Aubrey L. Haines Lecturer,
Department of Geography, Geology, and Planning,
Missouri State University

Since Yellowstone National Park's establishment, its extraordinary resources have been protected largely through the efforts of generation after generation of park managers, employees, and the many other people who care about the park's future. The challenges facing national parks have grown increasingly complex, and effective protection of their natural and cultural treasures requires active, informed management based on good science—science conducted by researchers outside as well as inside the National Park Service. It also requires partnerships to increase communication and collaboration on efforts that could not be carried out by the National Park Service alone.

The purpose of the biennial scientific conference on the Greater Yellowstone Ecosystem series, instituted in 1991, is to encourage awareness and application of wide-ranging, high-caliber scientific work on the region's natural and cultural resources. The wealth of subjects and issues to be explored in the Greater Yellowstone area provides both an unbounded font of research possibilities and an unflagging need for their results. This conference series provides a much-needed forum for knowledge sharing among park managers, the hundreds of researchers doing work here, and the general public.

The goal of the "10th Biennial Scientific Conference on the Greater Yellowstone Ecosystem, Questioning Greater Yellowstone's Future: Climate, Land Use, and Invasive Species," was to generate discussion on how changes in climate, land use, and invasive species are altering the ecology of Greater Yellowstone's public and private lands. More than 45 presentations were given on topics that included the past, current, and future possible effects of these ecosystem drivers on vegetation, wildland fire, land use, alpine glaciers, amphibians, aquatic resources, butterflies, elk, grizzly bears, mountain goats, pronghorn, wolves, plant and wildlife diseases, and human adaptations to the environment. Other conference highlights included interagency, interdisciplinary, and international keynote speeches, an extensive poster session, and a panel discussion of the 2009 "Greater Yellowstone Area Science Agenda Workshop," at which approximately 90 land managers and scientists identified priorities for ecosystem management in the region over the next 10–20 years.

The 200 participants at the conference—agency managers, scientists, university researchers and students, the public, and media representatives—shared an opportunity to help shape our understanding of some of the key ecological challenges this region faces and the strategies needed to address them. We hope that these conferences and their proceedings continue to contribute to professional knowledge and debate on the many aspects of this extraordinary area during an exceptionally challenging period in its history.

10th Biennial Scientific Conference on the Greater Yellowstone Ecosystem,
Planning Committee

Introduction and Welcome

Suzanne Lewis

Superintendent, Yellowstone National Park

Note: The text that follows is an edited transcription of the speaker's remarks at the conference.

Good morning. My name is Suzanne Lewis and I am superintendent of Yellowstone National Park. It is my great pleasure to welcome all of you here today for this exciting and important conference.

We want to make sure your visit is as fulfilling and fun as possible, so please let us know if you need anything Tami Blackford, Emily Yost, and Janine Waller, or check at the conference registration desk in the hotel lobby.

We in the National Park Service are realistic enough to know that it isn't just our sparkling personalities that attract so many people to these conferences. Yellowstone is a wonderful place to meet, and I hope you have all built some extra time into your schedules to get out in the park while you're here. But Yellowstone does present some hazards you won't encounter in most conference venues. Be careful out there. Some of our most famous scientific topics are wandering around on the lawns here at park headquarters right now. They get pretty worked up this time of year, so please be careful and keep your distance. When you leave a building, or if you're walking somewhere and must turn a blind corner, take a look around first, to avoid big surprises.

Today we celebrate a milestone in this conference series. This is the tenth time we have gathered to report and deliberate on the scientific issues of our region. Those of you who have been involved from the beginning know how much these conferences have contributed, not just to our management dialogues, but also to the knowledge and wonder we can impart to the millions of people who care about Yellowstone. The proceedings of the first nine conferences in this series amount to an encyclopedic resource for future visitors, managers, and researchers, and we're very proud of that. You are part of the most productive generation of researchers in Yellowstone's long and distinguished scientific history, and I thank you for all you've done to enrich the Yellowstone experience.

If we stand back a little farther from all this hard work and conversation, we can see that these conferences track the prevailing moods and priorities of their times. The very first conference in the series revealed our intense preoccupation with one of Yellowstone's most venerable controversies, the effects of our magnificent ungulate populations on our equally magnificent landscapes. Another time, we focused our energies and insights on the roles and fates of the charismatic native predators, whose future depends upon those controversial ungulates. In other conferences we have explored the place of humans in this landscape; we have penetrated the depths and mysteries of Yellowstone Lake; we have chronicled the reshaping of our ecosystem by non-native species; we have invited our African counterparts to share their experience and insights from living in close company with wildness at least as spectacular as Yellowstone's. And on three memorable occasions we have convened here to consider the effects and lessons of the monumental fires of 1988.

And yet for all of the intensity of the focus of each conference, we have fostered an interdisciplinary breadth, not just across scientific disciplines but across the humanities as well. I'm a historian by training, and I've always been pleased that we could attract so many leading figures

Figure 1. Yellowstone National Park Superintendent Suzanne Lewis.

from the social sciences into the Yellowstone conversation.

That interdisciplinary breadth is, I believe, our best hope for the future of places like Yellowstone. As the agenda for this tenth conference indicates, we are going to need to muster wisdom from all corners of our community if we are to successfully confront the demands of the future. It's easy to see that the preceding nine conferences have been preparing us for this one.

The three topics of this conference—climate, land use, and invasive species—command a great sense of urgency not just in Yellowstone but in American society and the world. Those of us in this room are collectively responsible for helping many other people come to terms with a future that is sometimes only dimly perceptible. But it is certain that whether the changes we foresee will be catastrophic or merely dramatic depends in good part on the strength of our science, and on our success in conveying the meaning of that science to a challenging variety of people—many of whom do not yet even believe that the changes we are concerned with are happening or are worthy of their notice. While I am sure that many of us in this room signed on to our respective careers with some idealized notion that we were going to try to *help* the world, I doubt that many of us realized the extent to which we might be called upon to help *save* it.

How's that for an opening charge for a conference? No pressure there, right? But I wouldn't put it so bluntly if I didn't have such high confidence that you have the necessary information, wisdom, and humility to do the job. I wish you well in your deliberations here, and I congratulate you again for all your good work on behalf of Yellowstone.

Thank you.

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Long-Term Observations of Boreal Toads at an ARMI Apex Site

Paul Stephen Corn[1], Erin Muths[2], and David S. Pilliod[3]

[1] U.S. Geological Survey, Northern Rocky Mountain Science Center, Aldo Leopold Wilderness Research Institute, 790 E. Beckwith Ave., Missoula, MT 59801, 406-542-4191, scorn@usgs.gov

[2] U.S. Geological Survey, Fort Collins Science Center, 2150 Centre Ave., Building C, Fort Collins, CO 80526, 970-226-9474, muthse@usgs.gov

[3] U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Snake River Field Station, 970 Lusk St., Boise, ID 83706, 208-426-5202, dpilliod@usgs.gov

Abstract

The U.S. Geological Survey's Amphibian Research and Monitoring Initiative (ARMI) is a national project with goals to monitor the status and trends of amphibians, conduct research on causes of declines, and provide information and support to management agencies for conservation of amphibian populations. ARMI activities are organized around extensive inventories and place-based monitoring (such as collaboration with the Greater Yellowstone Inventory and Monitoring Network), and intensive population studies and research at selected locations (apex sites). One such site is an oxbow pond on the Buffalo Fork near the Black Rock Ranger Station east of Grand Teton National Park. We have been conducting mark-recapture of boreal toads (*Anaxyrus boreas*) at Black Rock since 2002. In concert with studies of other toad populations in the Rocky Mountains, we have documented a high rate of incidence of the chytrid fungus *Batrachochytrium dendrobatidis* (Bd) and a negative rate of growth of the toad population, but not the population crash or extinction observed in other populations with high prevalence of Bd. Long-term observations at other ARMI apex sites have proven invaluable for studying effects of climate change on amphibian behavior, and the Black Rock site has been upgraded with onsite recording of weather data and auditory monitoring of other amphibian species. Continued research at Black Rock will be critical for understanding the interrelated effects of climate and disease on amphibians in the Greater Yellowstone Ecosystem.

The ARMI Effort

The Amphibian Research and Monitoring Initiative (ARMI) of the U.S. Geological Survey (USGS) is a national effort to document status and trends of amphibian populations on federal (mainly Department of Interior) lands, conduct research into causes of amphibian declines and malformations, encourage partnerships to expand the scope of monitoring efforts, and provide information that will assist land managers in protecting amphibian populations (Corn et al. 2005a). Monitoring and research is conducted by ARMI in a hierarchical manner, conceptualized as a pyramid, with relatively less effort at relatively more sites (for example, inventory work) forming the base, greater effort at a restricted number of sites in the middle (for example, monitoring occupancy in a defined area of inference such as a national park), and intensive effort at a few sites at the apex of the pyramid (Corn et al. 2005a).

ARMI in the Rocky Mountain Region. Nationally, ARMI is divided into seven regions, and USGS research zoologists Steve Corn and Erin Muths are the principal investigators in the Rocky Mountain Region (Montana, Wyoming, Colorado, and New Mexico). At the middle level of the ARMI pyramid, amphibian populations are monitored in the national parks on the Continental Divide: Glacier, Yellowstone, Grand Teton, and Rocky Mountain National Parks (Corn et al. 2005b). ARMI partners with the National Park Service Greater Yellowstone Inventory and Monitoring Network (GRYN) to conduct monitoring in Yellowstone and Grand Teton National Parks, where amphibians are considered one of GRYN's vital signs. Analysis of trends in amphibian populations is accomplished by examining the change in occupancy by each species in small drainages (catchments). Each catchment encompasses several individual wetlands that are searched for evidence that breeding has occurred. Multiple visits are conducted so that detection probabilities can be estimated to account for the possibility that a species could have bred at a site but been missed by the surveys (MacKenzie et al. 2006).

Middle-level occupancy monitoring targets all the amphibian species that occur in the study area, but monitoring at apex sites is usually focused on a single species and

Figure 1. West arm of the Black Rock apex monitoring site. Photo by Steve Corn, U.S. Geological Survey.

often employs intensive capture-recapture methods to estimate demographic parameters, including population size and survival. Research often addresses the environmental influences that affect populations. The ARMI Rocky Mountain Region conducts apex studies at several locations in Montana, Wyoming, and Colorado. For example, populations of boreal chorus frogs (*Pseudacris maculata*) near Cameron Pass in northern Colorado have been studied since 1986, making this one of the longest continuous amphibian studies in the world. Data from this site have contributed to our understanding of how exposure of amphibian embryos to ultraviolet radiation varies from year to year, driven by the dependence of breeding phenology on mountain snowpack (Corn and Muths 2002). At another apex site, ARMI has supported studies by two University of Montana graduate students on a population of Columbia spotted frogs (*Rana luteiventris*) occupying a high-elevation fishless basin in the Bitterroot Mountains. Frogs have been marked since 2000, and annual survival of post-metamorphic life stages is higher in years with smaller snowpacks (McCaffery and Maxell 2010). Such results are important in predicting responses of amphibian populations to climate change.

The Black Rock ARMI Apex Site. In the Greater Yellowstone Ecosystem, ARMI maintains an apex site east of Grand Teton National Park at an old oxbow of the Buffalo Fork near Bridger-Teton National Forest's Black Rock Ranger Station (Figure 1). This site, which we name Black Rock, supports breeding populations of four of the five amphibian species known to have occurred in the Jackson Hole area (Figure 2). Only the northern leopard frog (*Lithobates pipiens*), which has likely been extirpated from the area, is missing (and we have no evidence that this species ever occurred at Black Rock). The boreal toad is the primary species monitored at Black Rock. Studies began in 2003 after two of the authors (EM and DSP) received a grant from ARMI to examine the distribution of the amphibian chytrid fungus (*Batrachochytrium dendrobatidis* [Bd]) in the Rocky Mountains and its effects on the population dynamics of boreal toads. Adult toads are sampled on several occasions during the breeding season in May or June each year, and individuals are identified by their passive integrated transponder (PIT) tag that is inserted under the dorsal skin upon first capture. Some toads are sampled for Bd by running a cotton swab over the ventral skin. Swabs are submitted to a laboratory for detection of Bd DNA using polymerase chain reaction (PCR) analysis.

Amphibians are in decline worldwide and Bd is considered a leading cause (Collins and Crump 2009). Bd is suspected as the primary cause of the collapse of boreal toad populations in the southern Rocky Mountains, including the crash to near extinction of toads in Rocky Mountain National Park in the mid-1990s (Muths et al. 2003). The first component of the ARMI study documented that Bd is common throughout the Rocky Mountains, including at Black Rock. Muths et al. (2008) detected Bd at 64 percent of 97 study sites (clusters of wetlands within 3 km of one another) and in 23 percent of 1,151 boreal toads sampled. Despite the high prevalence of Bd, toad populations in the northern Rocky Mountains did not seem to be undergoing the sudden and steep declines seen in Colorado.

In the second component of the ARMI study, Pilliod et al. (2010) addressed the population-level effects of Bd infection by comparing demographic parameters at two sites with Bd present (Black Rock and Lost Trail National Wildlife Refuge, Montana) to a site free of Bd (Denny Creek, in the Sawatch Range, San Isabel National Forest, central Colorado). This study found high annual survival

(0.73–0.77) of adult toads that were not infected with Bd at all three locations, but at Black Rock and Lost Trail, toads that tested positive for presence of Bd had lower survival (0.42 and 0.53, respectively). As a consequence, the population at Denny Creek was stable, but numbers of adult toads at Black Rock and Lost Trail were declining 5–7 percent per year.

Black Rock has served as a site for related studies. One of the authors (PSC), with Sophie St.-Hilaire and Peter Murphy from Idaho State University, obtained research grants in 2006 and 2008 through the USGS Park Oriented Biological Support (POBS) program to document Bd in and around Grand Teton National Park and study the apparent differences in the consequences of Bd infection between toads in the northern and southern Rocky Mountains. Murphy et al. (2009) found Bd present at all 10 boreal toad breeding sites sampled, with a mean prevalence of 64.5 percent. In the laboratory, Bd isolated from toads collected at Black Rock killed toads as effectively as Bd isolated from Colorado, but recently metamorphosed toads from Black Rock survived longer than toadlets from Colorado. Papers describing the results of the second POBS study, involving field and laboratory data on behavioral characteristics of toads from Black Rock and Colorado that might affect the outcome of Bd infection, are currently in preparation. This study included radio telemetry of adult toads at Black Rock in 2008.

We intend to continue data collection at Black Rock for the foreseeable future, with several enhancements. We began using an automated recording system in 2009 to document breeding activity by boreal chorus frogs and Columbia spotted frogs. Because temperature is impli-

Figure 2. Amphibians that breed at Black Rock. Clockwise from upper left: boreal toad (*Anaxyrus boreas*), barred tiger salamander (*Ambystoma mavortium*), Columbia spotted frog (*Rana luteiventris*), and the boreal chorus frog (*Pseudacris maculata*). Photos by Steve Corn, U.S. Geological Survey.

cated in the presence and expression of Bd (Muths et al. 2008; Pilliod et al. 2010), we installed a weather station in 2009 to provide more precise climatic data. In 2010, we began marking both boreal toads and boreal chorus frogs at a newly constructed pond 400 m west of the oxbow. Finally, we have begun using quantitative PCR analysis of the Bd samples, which provides an estimate of zoospore density, rather than qualitative analysis, which provides a categorical assessment of the degree of infection. These additional data may prove useful, because population-level effects of Bd infection may be related to the severity of infection of individual animals (Briggs et al. 2010). The data collected at Black Rock already have proven extremely valuable to the study of amphibian populations in the Rocky Mountains. Because lengthy time series of amphibian population data are relatively rare, the longer we collect these data, the greater the contribution is likely to be.

We would like to thank the Buffalo Fork Ranger District of the Bridger-Teton National Forest for permissions and logistical support, Rick Scherer for population analyses, and Deb Patla, Blake Hossack, Sophie St.-Hilaire, Peter Murphy, and Chuck Peterson for observations, data on Bd, and assistance with fieldwork. Research has been conducted under Wyoming Game and Fish Department Chapter 33 Permit and Research Permits from Yellowstone and Grand Teton National Parks. This is contribution 368 of the U.S. Geological Survey Amphibian Research and Monitoring Initiative.

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