

Forest and Rangeland Ecosystem Science Center

Amphibian Research and Monitoring Initiative

Pacific Northwest Region 2010 Annual Report

PI: Michael J. Adams, USGS Forest and Rangeland Ecosystem Science Center, 3200 SW Jefferson Way, Corvallis, OR 97331. mjadams@usgs.gov, 541-758-8857.

20 December 2010



Rana cascadae (photo by B. McCreary)

U. S. Department of the Interior
U. S. Geological Survey

Disclaimer: This is an annual report. It is intended to provide an update on ARMI activities in the Pacific Northwest. Because it is an annual report and not a final product, it is not subject to peer review and does not attempt to draw any conclusions. Any analyses presented should be considered preliminary.

USGS Personnel

USGS FRES

Michael J. Adams, Supervisory Research Ecologist
R. Bruce Bury, Research Zoologist
Christopher A. Pearl, Wildlife Biologist
Stephanie Galvan, Wildlife Biologist
Nate Chelgren, Wildlife Biologist
Brome McCreary, Wildlife Biologist
David Pilliod, Research Ecologist

USGS NWHC

David Earl Green, DVM

USGS WRD

Chauncey Anderson, Hydrologist

USGS EROS Data Center

Bob Klaver

Other Collaborators

Jay Bowerman, Sunriver Nature Center
Cheryl Friesen, USFS
Meg Hahr, NPS
Sanjay Pyare, University of Alaska, Juneau
Barbara Samora, Mount Rainier National Park, Washington
Dr. Cynthia Tait, USFS
Rob Huff and Kelli VanNorman, BLM/USFS ISSSP
Lauri Turner, USFS
Terry Simpson, USFS
Wendy Palen, Simon Fraser University
Jamie Bettaso, USFWS
Liz Dent, Oregon Department of Forestry
Dave Schirokauer, Klondike Gold Rush NHP
Heather Ray, USFWS
Michelle Barry and Shannon Peterson, Klamath Basin Rangeland Trust
Rob Roninger, BLM
W. Chris Funk, Colorado State University

Authors of this report

Michael J. Adams, Christopher A. Pearl, Stephanie Galvan, Brome McCreary, Nate Chelgren, David Pilliod

Introduction

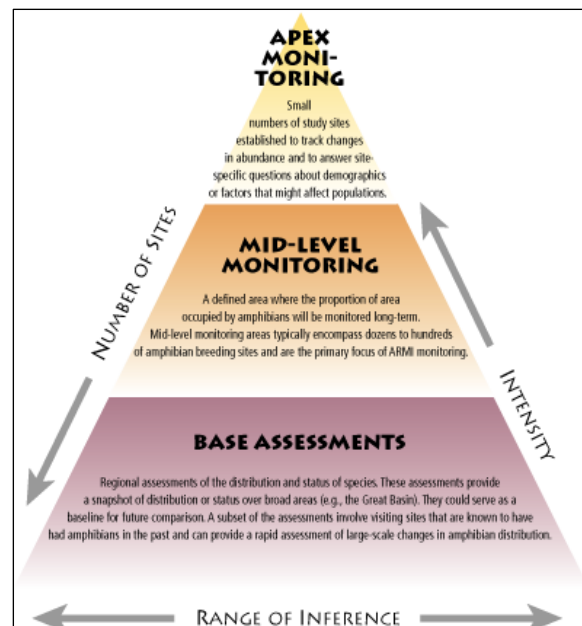
The Amphibian Research and Monitoring Initiative

The Amphibian Research and Monitoring Initiative (ARMI) was funded by Congress beginning in 2000 and continues indefinitely. The goals of ARMI are to: (1) establish a network designed to monitor the status and changes in the distribution and abundance of amphibian species and communities in the United States; (2) identify environmental conditions known to affect amphibians and document their differences across the Nation; (3) conduct research that identifies causes of amphibian population change and malformations; and (4) provide information to managers, policy makers and the general public in support of amphibian conservation. This initiative is led by the Biology Discipline of the USGS but also includes funding for the Water Discipline. The US Fish and Wildlife Service also receives funding that they use to assess amphibian malformations on refuges.

ARMI has adopted a hierarchical approach to monitoring. This hierarchy can be visualized as a pyramid. At the base, extensive but necessarily coarse measurements are made at many sites across the country or a region. At the apex, intensive research and population monitoring is conducted at a relatively small number of sites. Apex monitoring does not generally provide inference beyond the sites surveyed. In the middle level of the pyramid, monitoring directed towards detecting change in occupancy of species across the landscape is conducted. Mid-level monitoring involves selecting sites to provide broad inference to an area of interest.

Ideally, ARMI would provide unbiased, base-of-the-pyramid estimates of the status of most amphibians in most habitats across the United States. Realistically, several constraints prevent this approach. Primary among these constraints is the mandate of USGS to provide science support for the other DOI agencies. Other important constraints are that 1) there are few species distributed widely across the US, 2) species richness and habitat diversity vary widely among geographic regions, and 3) amphibians display a variety of reproductive modes and habitat associations. This diversity requires that a variety of sampling methods, rather than a single standardized approach, be used to detect and monitor amphibians across the country and even within regions.

Because of the constraints on standardization, ARMI has developed a modular approach that emphasizes monitoring at the mid-level and apex of the pyramid. The mid-level documents trends in site occupancy which may be the most useful metric for assessing changes in amphibian status. Mid-level monitoring areas can be virtually any defined area or set of areas within which the proportion of sites or area occupied by amphibians is of interest. At all levels of the pyramid, ARMI researchers are encouraged to form partnerships with other agencies, programs and researchers to broaden the scope of investigation.



This modular network of separate monitoring studies is held together by the production of unbiased estimates of occupancy (mid-level monitoring) and abundance (apex monitoring). These estimates, in aggregate, provide a means to broadly evaluate the status and trends of amphibians across all ARMI monitoring studies.

ARMI in the Pacific Northwest and Adjacent Aridlands

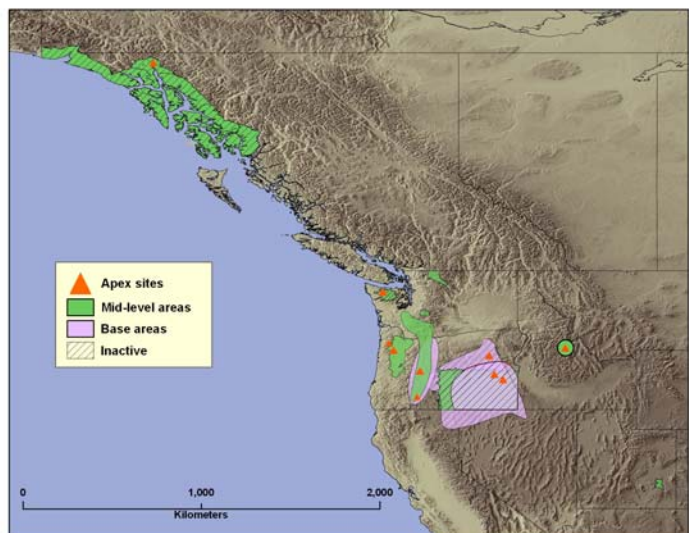
The Pacific Northwest region of ARMI (ARMI PNW) operates out of the Forest and Rangeland Ecosystem Science Center (FRESC) located in Corvallis, Oregon. It officially includes Washington, Oregon, Alaska, Idaho, Utah, and Nevada. The ARMI PNW region is characterized by a diverse array of ecosystems, ranging from rainforest to deserts and from seashore to alpine, and by large amounts of public lands.

Western North America is one of several regions worldwide with a concentration of amphibian declines. Some of the most prominent examples of decline include the Yosemite toad, mountain yellow-legged frog, California red-legged frog, and western toad. Perhaps the best documented decline in the Pacific Northwest is that of the Oregon spotted frog. Despite repeated surveys, this species is now only known to occur in fragmented populations in 10 – 30% of its former range. There are also indications that western toads and Columbia spotted frogs have declined in our region.

The biggest threats to amphibians in the Pacific Northwest, as is true elsewhere, are the loss and alteration of wetland habitat. Over 50% of the wetland habitat that was present in North America 100 years ago is now lost. In the Pacific Northwest, wetland loss occurs through urbanization, road construction, and agriculture. Aside from habitat loss and alteration, much evidence points to non-native species as a culprit in amphibian declines. Bullfrogs and a variety of non-native fish have all been shown to have negative effects and are widespread in our region. Finally, diseases such as chytridiomycosis have been found in the Pacific Northwest and are emerging as a leading hypothesis to explain amphibian declines in other parts of the world. Their effects in the Pacific Northwest are under investigation

ARMI PNW has focused heavily on partnering with other parties interested in amphibians to establish mid-level monitoring areas. If a partner will collect the data, we typically offer to help design monitoring programs, assist with training, facilitate data storage and QA/QC procedures, conduct annual and other periodic analyses of data, and report results and interpretation. However, in some cases we also do the data collection.

All of our monitoring projects involve annual analyses and detailed analyses. Annual



analyses and reports are designed to provide estimates of basic population parameters and updates on project status. In addition, they allow us to assess our techniques and make appropriate changes in a timely manner. Detailed analyses are focused on questions and hypotheses related to the monitoring project. In some cases, these may be methodological and in others, will relate to specific hypotheses about stressors or management activities. Detailed analyses are conducted approximately every five years by design and result in publications in the primary literature. This report contains our annual analyses as well as updates on all of our amphibian monitoring and any research projects that are specifically funded by ARMI.

ARMI monitoring locations in the Pacific Northwest, adjacent aridlands, and Alaska.

Location	State	Agency/Collaborator	Period	Primary Species
Apex Monitoring Sites				
Clear Lake	WA	NPS	2002-ongoing	<i>Rana cascadae</i>
Kingsbury Gulch	OR	BLM	2002-ongoing	<i>Rana luteiventris</i>
Willamette Valley	OR	USFWS	2002-ongoing	<i>Rana aurora</i>
Dilman Meadow	OR	BOR, USFS, USFWS, ODFW, Sunriver Nature Center	2002-ongoing	<i>Rana pretiosa</i>
Mink Lake	OR	USFWS, USFS, ODFW	2002-ongoing	<i>Rana pretiosa</i>
Bighorn Crags	ID	USFS	2005-ongoing	<i>Rana luteiventris</i>
Blue Mountain Grazing Sites	OR	USFS, USFWS	2002-ongoing	<i>Rana luteiventris</i>
Trask Watershed	OR	BLM, ODF	2007-ongoing	<i>Ascaphus truei</i>
Mid-level Monitoring Sites				
Oregon Spotted Frog	OR,WA	BLM, USFS, USFWS	2010-ongoing	<i>Rana pretiosa</i>
Olympic National Park	WA	NPS	2001-2002	<i>Rana cascadae</i> , <i>Ambystoma macrodactylum</i> , <i>Ambystoma gracile</i> , <i>Taricha granulosa</i>
Southeast Oregon	OR	BLM	2001-2003	<i>Rana luteiventris</i> , <i>Pseudacris regilla</i> , <i>Ambystoma macrodactylum</i>
Klondike	AK	NPS	2005-ongoing	<i>Anxyrus boreas</i>
Willamette Valley	OR	USFWS, BLM	2004-ongoing	<i>Rana aurora</i> , <i>Lithobates catesbeianus</i> , <i>Pseudacris regilla</i> , <i>Ambystoma gracile</i> , <i>Ambystoma macrodactylum</i> , <i>Taricha granulosa</i>
Canyonlands National Park	UT	NPS	2001-2006	<i>Bufo punctatus</i>
North Coast and Cascade Network	WA	NPS	No parameter estimates	<i>Rana cascadae</i> , <i>Ambystoma macrodactylum</i> , <i>Ambystoma gracile</i> , <i>Taricha granulosa</i>
Southeast Alaska	AK	Alaska Fish and Game, USFS, USFWS, NPS, University of Alaska	2005-ongoing/ in progress	<i>Bufo boreas</i> , <i>Taricha granulosa</i>

Location	State	Agency/Collaborator	Period	Primary Species
Bighorn Crags	ID	USFS	1994-ongoing	<i>Bufo boreas</i> , <i>Rana luteiventris</i>
Base level Inventories				
Southeast Oregon	OR	BLM, USFS	2009	<i>Rana luteiventris</i>
Oregon Cascades	OR	BLM, USFS, USFWS	2006	<i>Rana pretiosa</i>
Vicinity of Northern Great Basin	NV, OR	BLM, USFWS	2000-2003	<i>Rana luteiventris</i> , <i>Bufo boreas</i>
Oregon Cascades	OR	USFS, USFWS, NPS, ODFW	2001-2004	<i>Rana cascadae</i> , <i>Bufo boreas</i>

ODFW=Oregon Dept. of Fish and Wildlife

Monitoring Updates

Base Monitoring

Revisiting historical amphibian sites can provide a relatively fast assessment of amphibian status in a region. Between 2000 and 2003 we repeatedly surveyed historically documented sites for two species of concern in the northern Great Basin: the western toad (*Bufo boreas*) and the Columbia spotted frog (*Rana luteiventris*). Both of these species have experienced population declines in other parts of their ranges but their status was relatively unknown in our study area. Using occupancy models that take detection probabilities into account, we estimated that *B. boreas* occupies 49.5% (34.1% - 65.0%) of 34 historical sites and that *R. luteiventris* occupies 52.9% (43.5% - 62.3%) of its 30 historical sites. *B. boreas* was more likely to be detected at human-altered sites while *R. luteiventris* was more likely to be detected at sites that were deeper than other sites in our study. *B. boreas* was detected at three of 41 (7.3%) potential sites (located near historical sites) while *R. luteiventris* was detected at six of 16 (37.5%). At 187 randomly selected sites, *B. boreas* was detected at one and *R. luteiventris* at three sites. Given that the number of historical sites available for resurveys was small, these results should be interpreted with caution. Moreover, a species can shift its distribution away from historical sites due to habitat succession or metapopulation dynamics without necessarily declining. We suggest that there is sufficient evidence to conclude that *B. boreas* and *R. luteiventris* have declined in and around the northern Great Basin. However, relatively high occupancy of potential sites by *R. luteiventris* suggests they may not have declined as much as *B. boreas* in the region we surveyed. A paper presenting these results in detail was published as a part of the ARMI special feature in the journal *Alytes*.

We have also conducted a second historical site revisitation study at the same time as the study described above. This second study focused on the status of Cascades frog (*Rana cascadae*) and western toad (*Bufo boreas*) in the Oregon Cascade range, an area where declines in both species have been suggested. Between 2001 and 2004, we surveyed sites known to historically host breeding *R. cascadae* (N=67) and *B. boreas* (N=54). We have submitted this paper to the *Journal of Herpetology* and it is currently in revision. Cooperators include Char Corkran, and staff of US Forest Service (Willamette, Umpqua and Deschutes), US Fish and Wildlife Service, National Park Service, and Oregon Dept. of Fisheries and Wildlife. Funding came from ARMI Monitoring and USGS State Partnership program. We completed a manuscript that is in press at the journal *Diversity*.

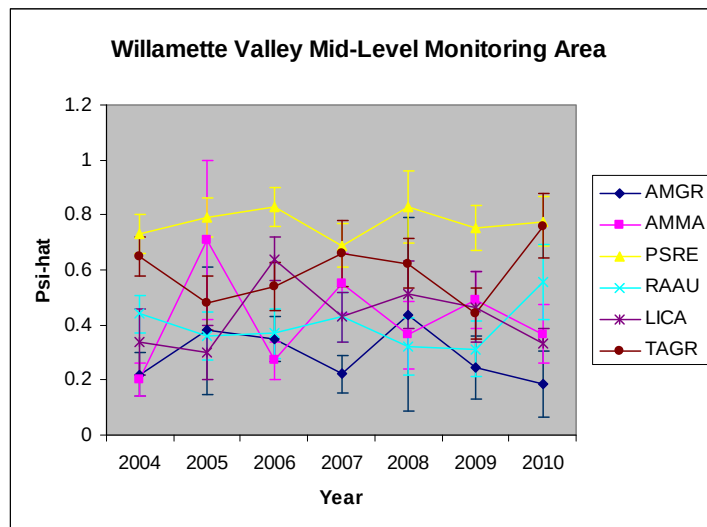
In 2009, with funding from the BLM/USFS Interagency Special Status/Sensitive Species Program (ISSSSP), we surveyed 40 known and historical *Rana luteiventris* sites in southeastern Oregon. We found frogs at 27 of these sites and found evidence of breeding at 12 sites. We published a report: Pearl et al. 2010. Columbia spotted frog (*Rana luteiventris*) in southeastern Oregon: A survey of historical localities, 2009. U. S. Geological Survey Open-File Report 2010-1235.

In 2009, we published an article in *Northwestern Naturalist* on breeding habitat and local population size in Oregon spotted frog (*Rana pretiosa*). This paper resulted from surveys across the state of Oregon, which is the core of this species' extant range. The objective of the study was to update and expand understanding of the status of *R. pretiosa*, which has experienced pronounced losses in parts of its range. We included known and suspected historical sites in the survey pool, as well as sites that were within 1 km of historical localities. Our main conclusions from the study were that sites with other breeding sites nearby have more *R. pretiosa* egg masses than those lacking proximal breeding sites, and that breeding sites where fish predators have direct access to *R. pretiosa* overwintering habitat (springs and flowing channels) have less breeding than sites where frog overwintering habitat is less accessible to fish. The study also suggests that Klamath populations are likely to be at greater risk than those in the Deschutes. This work was supported by the Interagency Special Status/Sensitive Species Program (BLM/FS), USGS-FRESC, ARMI, and US Fish and Wildlife Service.

Mid-level Monitoring

Willamette Valley: USFWS and BLM are partners but this project is completely funded

by our regional ARMI funds. The primary objectives of this project are to 1) determine the relationship between native amphibians and introduced fish and bullfrogs; 2) determine if the extinction probability of native amphibians is related to presence of introduced fish and bullfrogs; and, 3) provide regular (usually annual) unbiased estimates of occupancy by native amphibians for wetlands on DOI lands in the Willamette Valley. The specific range of inference for this study is all wetlands on DOI lands in the

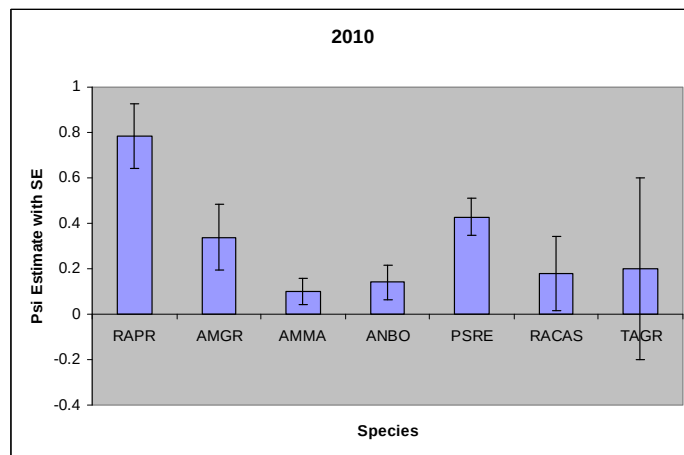


Willamette Valley that tend to persist through at least June in most years (the time when many amphibians are able to complete metamorphosis). These wetlands are mostly on USFWS lands (William L. Finley NWR, Baskett Slough NWR, Ankeny NWR, and one subunit of Finley NWR (Snag Boat Bend), but we also included BLM lands in the "West Eugene Wetlands". Our study area includes five counties in the central and south Willamette Valley of western Oregon. We started with 42 wetlands in 2004 but have lost 3 wetlands that no longer have sufficient water for breeding. In 2010, we began to only survey a subset of the 39 wetlands each year but the parameter estimates will continue

to apply to the same range of inference. This was done so that we could shift some resources towards a new mid-level monitoring area. We surveyed 8 wetlands over a 1 week period in late June.

Oregon Spotted Frog:

In 2010 we began a partnership with the USFS/BLM Interagency Special Status Sensitive Species Program to monitor the Oregon Spotted Frog. The direct range of inference is to areas around the distribution of Oregon Spotted Frog in the Oregon Cascades but a future analysis could incorporate monitoring data from the rest of the range. Our objectives are to: 1) determine the trend in the proportion of sites occupied; 2) estimate the influence of hypothesized environmental factors on the probability of patch colonization or patch extinction; and 3) survey all current sites every 4 years. In the near term we seek to verify that we are adequately dealing with variation in detection probability and make any adjustments to our protocol that are needed. In 2010 we sampled a total of 39 sites with a random subset receiving 2 or 3 repeat surveys. Our focus is on the Oregon spotted frog but we obtained data for a total of 7 species. There was no evidence of lack of fit for the Oregon Spotted Frog model, suggesting that we had an adequate model for detection probability. Confidence limits on the estimate of psi are rather wide and the estimates of psi are very model dependent which is unsatisfying but these are things that should improve rapidly over the first few years of monitoring.



North Coast and Cascades

Network, NPS: We spent several years working with this network to develop a monitoring approach. The data currently being collected are very scaled back from the original design. It may be possible to estimate occupancy at long intervals but in general, these data are too sparse for a mid-level approach.

Bighorn Crags: David Pilliod completed the 17th year (1994-2010) of mid-level monitoring of lakes in the Bighorn Crags, Salmon-Challis National Forest, Idaho. Columbia spotted frog (*Rana luteiventris*) occupancy (psi) was 0.274 with a detection probability (p) of 1.0 across 51 lakes and ponds.

Canyonlands National Park: We targeted the Colorado Plateau for a mid-level monitoring area because it is a highly neglected region in terms of our knowledge of amphibian status (the most common species are *Bufo woodhousii* and *B. punctatus*). Tim Graham (USGS SBSC) led this effort. This was one of the most difficult mid-level monitoring areas to establish because of the inaccessibility of the terrain coupled with the unpredictable and ephemeral nature of amphibian habitats in that landscape. Canyonlands NP indicated that amphibian monitoring is a priority for them and our intent has always been to partner with them to monitor amphibians. However, CANY was unable to garner the necessary resources and the funds that ARMI could provide would not be enough for even a minimal effort. Thus, our plan is to communicate with the NPS

to find opportunities to intermittently sample amphibians in this region. Data collected to date can serve as a basis for future comparison.

Southeast Alaska: In 2004, we made two visits to Juneau to meet with the partner agencies and communicated extensively with Sanjay Pyare about a possible mid-level monitoring area. We have produced a preliminary design. Pilot data were collected in 2005 and 2006. In 2007 and 2008, we met with Dr. Pyare to evaluate the data. The future of this project is unclear. The role of ARMI PNW will be to help with data, analysis, and reporting as needed and to transfer parameter estimates to the ARMI results database.

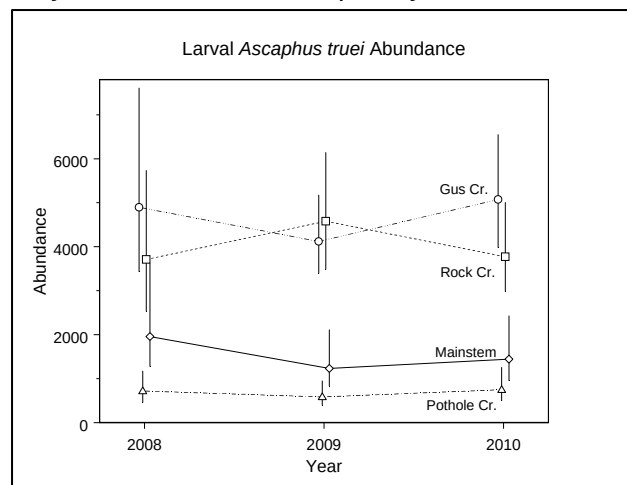
Klondike Goldrush National Historic Park: This park is interested in monitoring Western Toads. We have spent several years helping them search for suitable methods to deal with the scarcity of toads and the complexity of habitat. We currently think that this could work as a mid-level monitoring area where approximately 40 sites are monitored and with an occupancy rate of about 0.25. The future of this project is unclear.

Olympic National Park: The Olympic National Park mid-level monitoring area was cancelled because the park decided that it could not afford to support any amphibian monitoring. Data were collected for the first two years of a 4 year rotating frame design under a matching funds arrangement. No future mid-level monitoring is planned for Olympic.

Southeast Oregon: We also chose to cancel the Southeast Oregon mid-level monitoring area. The species we were most interested in proved to be too rare for an occupancy approach and attempts to bias the sample in a way that produce higher occupancy estimates failed. We determined that continuing with this monitoring study would be unlikely to produce interesting information about amphibian status and trends.

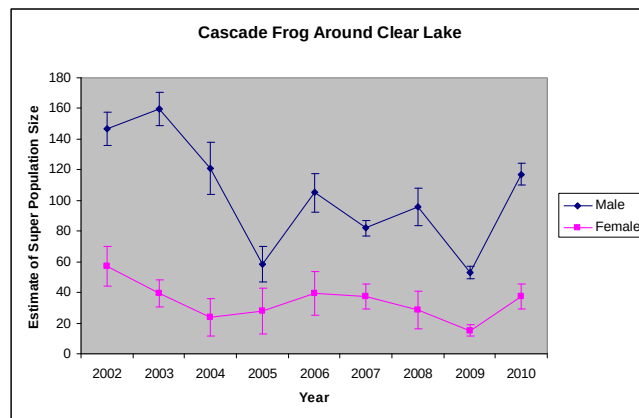
Apex Monitoring

Trask Watershed: In 2008, in coordination with Oregon Department of Forestry, Weyerhaeuser Company, US Bureau of Land Management, and Oregon State University we began monitoring stream amphibian populations at 18 sites in four basins as a component of the Trask Watershed Study. This is a multi-disciplinary research project designed to evaluate the impacts of current forest management practices on aquatic ecosystems. Multiple headwater basins will be experimentally clearcut harvested in 2012 along the small non-fish bearing streams. The results from this experimental study will provide resource managers with an expanded understanding of both direct and indirect effects of forest management on the Northwest's unique stream amphibian fauna in a comprehensive ecosystem context. Long-term monitoring will examine annual and spatial variation in



abundance, movement, survival, ontogenetic development and growth of amphibians. From 2008-2010, nearly 22,000 amphibians were captured at the 18 sites revealing spatial variation in several responses even before the experimental treatment has begun.

Clear Lake: We are monitoring movement and size of a Cascades frog (*Rana cascadae*) population in a cluster of ponds near Clear Lake in the Seven Lakes Basin of Olympic National Park. Cascades frogs are thought to be declining in parts of their range and this study will help us understand their natural history in a sub-alpine environment. Sampling in 2010 was on July 24-27. We use a robust design approach to analyze the complete dataset, treating the secondary sampling periods as closed and the primary periods as open. This means that immigration, emigration, mortality, and reproduction can occur between years but not during the 3 days of sampling each year. The probability of capture and of recapture was related to the air temperature during our surveys and captures were particularly low in 2004 and 2005 due to cold weather. Recaptures were modeled as an offset of captures. We modeled emigration using a random temporary emigration approach that sets $\gamma' = \gamma''$ (γ'' is the probability that a non-emigrant the previous year is a temporary emigrant in the current year [meaning it is absent from the study area or otherwise unobservable]; γ' is the probability that a frog that was a temporary emigrant last year is still a temporary emigrant this year). We suspect that many of the frogs move away from the breeding ponds shortly after breeding and are therefore unobservable using our sampling techniques in years when we are phenologically late sampling the study area (2004, 2005, and 2006). Thus, we include an additional term in the model to relate temporary emigration to site phenology. This improves the fit substantially. We use the function $N_i/(1-\gamma_i)$ to estimate the total size of the population on the south side of Clear Lake including temporary emigrants. This is referred to as the superpopulation. We used the delta method to estimate the SE for the superpopulation estimates. These values are shown in the figure.



Bighorn Crags: David Pilliod completed the 6th year (2005-2010) of a mark-recapture study at apex site (metapopulation of 6 breeding sites) in the Bighorn Crags, Salmon-Challis National Forest, Idaho. Survival probability of Columbia spotted frogs (*Rana luteiventris*) was 0.82 (0.76-0.87) with a detection of 0.2 (0.13-0.29).

Kingsbury Gulch: The main pool at this site was filled in with sand and silt during a spring flood event in 2006, and suitable habitat for Columbia spotted frogs decreased dramatically every year since then. Standing water has been increasingly encroached upon by an existing grove of *Typha* along with other early successional vegetation. We checked the site for water in early August, and the main pool continues to be completely filled in with silt and sand. There was approximately 5 cm of soft mud at the lowest

point, but no standing water. Crews probed the muddy areas but did not detect amphibians. The reach immediately below the pool had deeper mud (about 13 cm), but did not yield any amphibians.

We will continue to opportunistically monitor this site, but it appears that it is unable to support Columbia spotted frogs in its current state. However, there is patchy, marginal habitat upstream and perhaps on private land downstream that may serve to source our survey site if conditions there improve.

Year	Unique Captures	N-hat (SE)	95% CI
2002	46	74 (7.777)	63-93
2003	116	211 (13.915)	188-242
2004	142	152 (5.425)	146-169
2005	112	126 (7.658)	116-150
2006	29	30 (1.5495)	30-38
2007	11	18 (7.861)	13-51
2008	13	14 (1.760)	14-24
2009	0	-	-
2010	0	-	-

Willamette Valley: We initiated egg mass counts for northern red-legged frog (*Rana aurora*) in 2000 to monitor breeding population size at a network of ponds in western Oregon's Willamette Valley. The Oregon Department of Fish and Wildlife (ODFW) has designated *R. aurora* as a Sensitive Species in this region, which is characterized by intensive agriculture and increasing urbanization. Concern over status of *R. aurora* is based on reports of declines, extensive habitat modification, and broad distribution of non-native predators (e.g., fish, bullfrogs). Information on *R. aurora* trends is lacking and has been requested by ODFW. Surveys in 2010 were between February 2nd and February 25th.

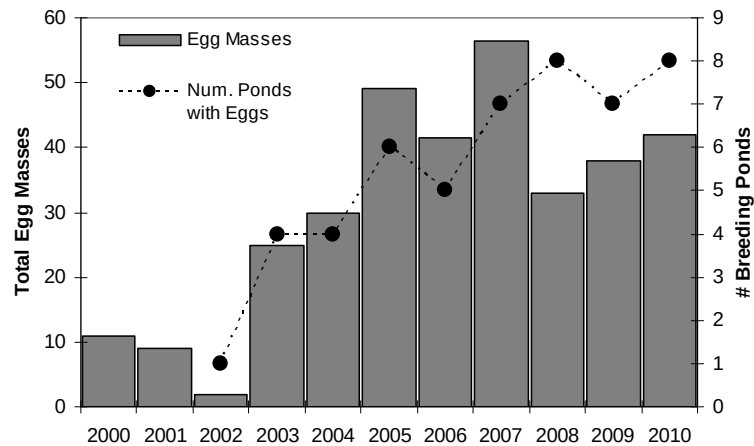
	Number of Ponds	Mean # <i>R. aurora</i> egg masses	Median # <i>R. aurora</i> egg masses	Range of egg mass counts	Winter Ppt (cm) ¹
2000	1	13	13	13-13	96.8
2001	2	2.5	2.5	0-5	48.2
2002	2	12.5	12.5	6-19	88.9
2003	3	16	16	0-32	99.8
2004	5	11.8	14	2-20	94.1
2005	5	13.4	9	0-27	61.1
2006	5	17.2	20	4-28	112.0
2007	4	9.5	6.5	2-23	96.0
2008	4	14.25	8.5	0-40	84.9
2009	4	15.5	11.5	0-39	68.1
2010	4	14.75	10.5	0-38	99.2

¹ Total precipitation for Oct-June water year (e.g., 2000 data includes Oct 1999 - June 2000) at Eugene Mahlon Sweet Airport Station, OR (<http://www.ncdc.noaa.gov/oa/climate/stationlocator.html>).

This update includes breeding counts from a set of core ponds on reserves managed by the US Fish and Wildlife Service (USFWS) and ODFW in the mid-Willamette Valley. We do not include data from one of our core sites in 2007 through 2010 due to poor survey conditions. Partners in this monitoring effort are: USFWS (WL Finley NWR, Ankeny NWR), ODFW (EE Wilson Wildlife Area), and Oregon State University, Fisheries and Wildlife Department (survey volunteers).

Dilman Meadow:

ARMI PNW is collaborating with a multiagency group to monitor a translocated population of *Rana pretiosa* (Oregon spotted frog). Partners include U. S. Bureau of Reclamation, U.S. Fish and Wildlife Service (Bend Field Office), US Forest Service (Deschutes National Forest), and Sunriver Nature Center. *Rana*



pretiosa is estimated to be lost from >70% of its historical range and is a candidate for listing under the ESA. Dilman Meadow is one of few *R. pretiosa* populations that lacks non-native species and offers many opportunities to better understand the species biology and response to habitat change. Our objective is to track population response to translocation and to provide information on options for creating and enhancing habitat. In 2001, we translocated eggs, juveniles and adults from a small population of *R. pretiosa* that was to be destroyed, into 6 newly created ponds in Dilman Meadow. These ponds were created by blasting and have experienced marked vegetation succession. In 2004, three additional ponds were created by excavation. We are monitoring the abundance, survival, and habitat use of the population using a combination of techniques. This population is among the most heavily marked for the species and a large majority of adults carry individual marks (PIT tags). Our yearly egg counts (figure below) suggest *R. pretiosa* breeding increased steadily between the first spring after translocation (2002) and 2005. Data from 2000 and 2001 were egg mass counts from the frogs' original habitat that was destroyed. 2007 was the highest count of the study. We found *R. pretiosa* breeding in most (77 – 88%) of the 9 ponds in the meadow since 2007. We found adult *R. pretiosa* in all 9 ponds in each summer from 2008 to 2010. Egg mass counts have increased slightly since the recent low in 2008. That coincided with vegetation removal from several of the original blasted ponds in winters of 2008-2009 and 2009-2010. We plan to monitor the Dilman Meadow population in the future with particular interest in whether there is evidence of shifting breeding use related to habitat succession. We published a paper on this project in 2008: Chelgren, N. D., C. A. Pearl, M. J. Adams, and J. Bowerman. 2008. Demography and movement in a relocated population of Oregon Spotted Frogs (*Rana pretiosa*): influence of season and gender. Copeia 2008:742-751.

Mink Lake Basin: In collaboration with the Willamette National Forest, USFWS and Oregon Department of Fish and Wildlife, USGS FRESC monitors Oregon spotted frog (*Rana pretiosa*) status and inter-wetland movement in the Mink Lake basin (upper Willamette River drainage). It has been estimated that *R. pretiosa* is lost from >70% of its historical range. This reduction is particularly acute in the Willamette Basin in Oregon, where *R. pretiosa* is estimated lost from >90% of historical range and is presumed extirpated from lowlands. All of the three known remaining populations are in elevations > 4000 ft elevation. Our work in the Mink Lake basin focuses on two breeding sites and

associated wetlands just below the Cascade crest in the Three Sisters Wilderness. We used mark-recapture sampling and modeling in program CAPTURE to estimate numbers of adult and sub-adult *R. pretiosa* in August 2010. At the Unnamed Marsh breeding site, we captured 37 frogs over three sampling days; a jackknife model estimated the local population ($N\text{-hat}$) to be 60 ± 7 SE (95% CI = 50 – 78). We captured two additional adult frogs approximately 130-m away from the breeding site at a small pond where we typically find small numbers of adults but have never observed breeding. Both frogs were marked at the same small pond in previous years, and neither has been detected at the main breeding site over the same period. At the Penn Lake breeding complex, we captured a total of 142 frogs over three sampling days; a jackknife model estimated local population ($N\text{-hat}$) to be 245 ± 15 SE (95% CI = 221 – 278). We found single frogs at two sites ca. 275 and 430 m from the historical breeding site at Penn Lake; one of these adults was found at the same site in 2009. We sporadically find adults at these sites as well as 2 others in the complex, but we have yet to find evidence of breeding at these satellite sites. Continued monitoring of these sites may help us understand dispersal or seasonal use of non-breeding sites in this highly aquatic amphibian.

Blue Mountain Grazing Sites: The Columbia spotted frog (*Rana luteiventris*) is considered a Sensitive Species in Oregon, and information on status has been requested by the Oregon Department of Fish and Wildlife, US Forest Service, and US Fish and Wildlife Service. Livestock grazing is commonly listed among the threats to *R. luteiventris* populations. USGS FRESA was awarded an ARMI research grant to study responses of Columbia spotted frog (*Rana luteiventris*) to the removal of livestock grazing at ponds in northeastern Oregon. This research was in collaboration with the Wallowa-Whitman National Forest, and was completed in 2006. Results of the research were published in *Journal of Herpetology* in 2009. We continue to monitor *R. luteiventris* breeding at a subset of the original study sites. We conducted egg mass counts at 12 breeding sites: two sites are in the Powder River drainage, four in the upper Burnt River drainage, and six in the lower Burnt River drainage. Sites range from 1340 to 1800 meters elevation. The table below summarizes egg mass counts at sites where our observations suggested breeding was complete at the time of our last survey. In 2010, surveys were on April 27-28, May 12-13, and June 2. Our aim is to continue to monitor *R. luteiventris* breeding.

	Number of ponds	Mean # <i>R. luteiventris</i> egg masses	Median # <i>R. luteiventris</i> egg masses	Range of egg mass counts
2002	11	11	7	2-32
2003	12	8.8	8.5	1-17
2004	12	5.3	4.5	0-12
2005	12	5.9	5	0-16
2006	12	5.9	6	0-19
2007	4	4.3	3.5	3-7
2008	6	6.5	7	1-13
2009	12	5.1	3	0-20
2010	12	3.8	3	0-11

Research Updates

Habitat Restoration for Oregon Spotted Frog

In 2007, ARMI PNW joined a team of collaborators (US Fish and Wildlife Service, Klamath Basin Rangeland Trust, and a private landowner) to monitor responses of

Oregon spotted frogs (*Rana pretiosa*) in a riparian restoration project in Klamath Basin, Oregon. The main objective of the restoration work is to improve habitat for salmonid fish by reestablishing flow of Crane Creek and associated springs into the historical meandering channel. The main flow on the site comes from cold springs and had been redirected into a system of ditches for drainage and irrigation. A population of *R. pretiosa* occupied the warm waters of the remnant meander channel that was isolated from the ditch system. We collected frogs from the meander channel to reduce chances of being harmed by channel excavation in the core reach of the project. Upon completion, habitat on the core site included the restored meandering stream channel, 6 constructed ponds, 3 off-channel emergent wetlands and emergent marsh fringes along the creek. Additional ponds were created upstream (1 pond) and downstream (4 ponds) of the core reach. Our goal is to monitor *R. pretiosa* breeding and adult numbers and to gain a coarse understanding of frog movement in a restored wetland complex. We are also teaming with the lab of Dr. Chris Funk to examine population genetics of *R. pretiosa* in this managed landscape.

We released 78 individually-marked *R. pretiosa* into three newly constructed ponds at the upstream end of the system in October 2007. We found 18 egg masses along the main reach in spring 2008, 14 (78%) of which were along the sides of the creek. Our surveys in spring of 2009 detected 13 *R. pretiosa* egg masses in the main study reach. Oviposition sites in 2009 had shifted away from the creek to off-channel habitats: 62% of detected egg masses were in constructed ponds and adjoining wetlands. Summer sampling in 2008 confirmed that at least 19 of our founding adult and subadult *R. pretiosa* survived the reintroduction and were present in the study area after their first winter. We detected 3 additional *R. pretiosa* from the reintroduced group in 2009 that we did not detect in 2008, raising the minimum number of frogs that survived the reintroduction to 22. We found 7 *R. pretiosa* egg masses in 5 oviposition sites in the core reach in spring 2010. Our mark-recapture sampling in September 2010 documented 98 unique juvenile and 46 different adult and subadult *R. pretiosa*. Summer water levels across the site were high in 2010 relative to prior years. We suspect this high water was related to the appearance of American bullfrog (*Lithobates catesbeianus*) in the restored reach after 2 years where we did not detect them. We have support for field work in 2011 and hope to extend monitoring for another 1-2 years to better assess the status of the bullfrog invasion and whether the *R. pretiosa* population is stabilizing.

Automated Amphibian Digital Identification System. David Pilliod received funding beginning in FY08. The system was developed for northern leopard frogs and tested on a captive population. A beta version of the software will soon be available for download from ARMI's website. Additional modifications will be made following beta testing by the research community.

The effects of cattle grazing and related habitat alteration on Columbia spotted frog populations in Oregon. In 2002 and 2003 ARMI PNW was awarded research funding to study the effects of cattle grazing on Columbia spotted frogs in the Blue Mountains of northeastern Oregon. This was a manipulative experiment with pre- and post-treatment sampling focused on population-level amphibian responses to the full and partial exclusion of grazing at 12 randomly chosen ponds. We also monitored general habitat characteristics including measurements of water quality. This study is complete and a manuscript has been published in the *Journal of Herpetology*. We now treat this as an ARMI Apex site and continue some basic monitoring (i.e., egg mass counts) using our regional monitoring funds. We hope to do a follow-up paper around 2014.

Using multilevel spatial models to understand salamander site occupancy patterns after wildfire. Studies of the distribution of elusive forest wildlife have suffered from the confounding of true presence with the uncertainty of detection. Occupancy modeling, which incorporates probabilities of species detection conditional on presence, is an emerging approach for reducing observation bias. However, the current likelihood modeling framework is restrictive for handling unexplained sources of variation in the response that may occur when there are dependence structures such as smaller sampling units that are nested within larger sampling units. We used multilevel Bayesian occupancy modeling to handle dependence structures and partition sources of variation in occupancy of sites by terrestrial salamanders (family Plethodontidae) within and surrounding an earlier wildfire in western Oregon, USA. Comparison of model fit favored a spatial N-mixture model that accounted for variation in salamander abundance over models that were based on binary detection/non-detection data. Though catch per unit effort was higher in burned areas than unburned, there was strong support that this pattern was due to a higher probability of capture for individuals in burned plots. Within the burn the odds of capturing an individual given it was present were 2.06 times the odds outside the burn, reflecting reduced complexity of ground cover in the burn. There was weak support that true occupancy was lower within the burned area. While the odds of occupancy in the burn were 0.49 times the odds outside the burn among the five species, the magnitude of variation attributed to the burn was small in comparison to variation attributed to other landscape variables and to unexplained, spatially autocorrelated random variation. While ordinary occupancy models may separate the biological pattern of interest from variation in detection probability when all sources of variation are known, the addition of random effects structures for unexplained sources of variation in occupancy and detection probability may often more appropriately represent levels of uncertainty. Chelgren, N. D., M. J. Adams, L. L. Bailey, and R. B. Bury. 2010. Using multilevel spatial models to understand salamander site occupancy patterns after wildfire. Ecology:in press.

Using occupancy models to understand the distribution and prevalence of an amphibian pathogen, Batrachochytrium dendrobatidis. *Batrachochytrium dendrobatidis* is a fungal pathogen that is receiving attention around the world for its role in amphibian declines. Study of its occurrence patterns is hampered by false negatives: the failure to detect the pathogen when it is present. Occupancy models are a useful but currently underutilized tool for analyzing detection data when the probability of detecting a species is less than 1. We use occupancy models to evaluate hypotheses concerning the occurrence and prevalence of *B. dendrobatidis* and discuss how this application differs from a conventional occupancy approach. We found that the probability of detecting the pathogen, conditional on presence of the pathogen in the anuran population, was related to amphibian development stage, day of the year, elevation, and human activities. *B. dendrobatidis* was found throughout our study area but was only estimated to occur in 53.4% of 78 populations of native amphibians and 66.4% of 40 populations of non-native *L. catesbeianus* tested. We found little evidence to support any spatial hypotheses concerning the probability that the pathogen occurs in a population, but did find evidence of some taxonomic variation. We discuss the interpretation of occupancy model parameters, when, unlike a conventional occupancy application, the number of potential samples or observations is finite. Adams, M. J., N. D. Chelgren, D. Reinitz, R. A. Cole, L. J. Rachowicz, S. Galvan, B. McCreary, C. A. Pearl, L. L. Bailey, J. Bettaso, E. L. Bull, and M. Leu. 2010. Using occupancy models to understand the

distribution of an amphibian pathogen, *Batrachochytrium dendrobatidis*. Ecological Applications 20:289-302.

Reimbursable and Leveraged Funding

Total reimbursable and leveraged funding in FY10 was about \$160K or 75% of the USGS funding to the Pacific Northwest Region.

Recipient/Cooperator	Funding Source	Amount	Reimbursable (R) or Leveraged (L)	Project
Mike Adams	Oregon Department of Forestry	\$57000	R	<i>Effects of timber harvest on stream amphibians</i>
Mike Adams	BLM	\$30000	R	<i>Historical site surveys for Columbia Spotted Frog</i>
Mike Adams	BLM/USFS	\$25000	R	<i>Oregon Spotted Frog Mid-Level monitoring</i>
Mike Adams	USFS	\$15000	R	<i>Historical site surveys for Columbia Spotted Frog</i>
Mike Adams	Oregon Community Foundation	\$5000	R	<i>Monitoring Oregon Spotted frog at Dilman Meadow</i>
Mike Adams	USFWS	\$15000	R	<i>Restoration/Monitoring for Oregon Spotted Frog at Crane Cr</i>
Mike Adams	USFWS	\$10000	R	<i>Monitoring Columbia Spotted Frog in Nevada</i>
Jay Bowerman	Sunriver Nature Center	\$3000	L	<i>Monitoring Oregon Spotted Frog at Dilman Meadow</i>

Products

- 2011 Adams MJ, Pearl CA, Galvan SK, McCreary B. Non-native species impacts on pond occupancy by an anuran. *Journal of Wildlife Management* 74:*in press*.
- 2011 Chelgren ND, Adams MJ, Bailey LL, Bury RB. Using multilevel spatial models to understand salamander site occupancy patterns after wildfire. *Ecology* 92:*in press*.
- 2010 Arkle, RS and Pilliod DS. Prescribed fires as ecological surrogates for wildfires: a stream and riparian perspective. *Forest Ecology and Management* 259: 893-903.
- 2010 Pearl CA, Galvan SK, Adams MJ, McCreary B. 2010. Columbia spotted frog (*Rana luteiventris*) in southeastern Oregon: a survey of historical localities, 2009. Open-File Report 2010-1235, U.S. Geological Survey. 96pp.
- 2010 Arkle, RS, Pilliod DS, and Strickler K. Fire, flow, and dynamic equilibrium in stream macroinvertebrate communities. *Freshwater Biology* 55:299-314.
- 2010 Hossack BR, Adams MJ, Grant EHC, Pearl CA, Bettaso JB, Barichivich WJ, Lowe WH, True K, Ware JL, Corn PS. 2010. Low prevalence of chytrid fungus (*Batrachochytrium dendrobatidis*) in amphibians of U. S. headwater streams. *EcoHealth* 44:253-260
- 2010 Murphy, MA, Dezzani R, Pilliod DS, and Storfer A. Landscape genetics of high mountain frog metapopulations. *Molecular Ecology* 19:3634-3649.
- 2010 Adams MJ, Chelgren ND, Reinitz D, Cole RA, Rachowicz LJ, Galvan S, McCreary B, Pearl CA, Bailey LL, Bettaso J, Bull EL, Leu M. Using occupancy models to understand the distribution and prevalence of an amphibian pathogen, *Batrachochytrium dendrobatidis*. *Ecological Applications* 20:289-302.
- 2010 Pilliod, DS, Hossack BR, Bahls PF, Bull EL, Corn PS, Hokit G, Maxell BA, Munger JC, and Wyrick A. Nonnative salmonids affect amphibian occupancy at multiple spatial scales. *Diversity and Distributions* 16:959-974.
- 2010 Pearl CA, Adams MJ, Bury RB, Wentz WH, McCreary B. Evaluating Amphibian Declines with Site Revisits and Occupancy Models: Status of Montane Anurans in the Pacific Northwest USA. *Diversity* 1:166-181.
- 2010 Shive, JP, Pilliod DS, and Peterson CR. Hyperspectral analysis of Columbia spotted frog habitat. *Journal Wildlife Management* 74:1387-1394.
- 2009 Pearl, CA, Bowerman J, Adams MJ, and Chelgren ND. 2009. Widespread occurrence of the chytrid fungus *Batrachochytrium dendrobatidis* on Oregon Spotted Frogs (*Rana pretiosa*). *EcoHealth* 6:209-218.
- 2009 Adams MJ, Pearl CA, McCreary B, Galvan SK, Wessell SJ, Wentz WH, Anderson CW, Kuehl AB. The short-term effect of cattle exclosures on Columbia Spotted Frog (*Rana luteiventris*) populations and habitat in Northeastern Oregon, USA. *Journal of Herpetology* 43:132-138.
- 2009 Pearl CA, Adams MJ, Leuthold N. Breeding habitat and local population size of the Oregon spotted frog (*Rana pretiosa*) in Oregon, USA. *Northwestern Naturalist* 90:136-147.
- 2008 Adams MJ, Galvan SK, Scalera R, Grieco C, Sindaco R. *Batrachochytrium dendrobatidis* in amphibian populations in Italy. *Herpetological Review* 39:324-326.
- 2008 Funk WC, Pearl CA, Draheim HM, Adams MJ, Mullins TD, Haig SM. Range-wide phylogeographic analysis of the spotted frog complex (*Rana luteiventris* and *R. pretiosa*) in northwestern North America. *Molecular Phylogenetics and Evolution* 49:198-210.
- 2008 Scalera R, Adams MJ, Galvan SK. Occurrence of *Batrachochytrium dendrobatidis* in amphibian populations in Denmark. *Herpetological Review* 39:199-200.
- 2008 Chelgren ND, Pearl CA, Adams MJ, and Bowerman J. 2008. Demography and movement in a relocated population of Oregon Spotted Frogs (*Rana pretiosa*): influence of season and gender. *Copeia* 2008:742-751.
- 2008 McCreary B, Pearl CA, Adams MJ. A Protocol for Aging Anurans Using Skeletochronology. US Geological Survey Open-File Report 2008-1209.
- 2008 Petrisko JE, Pearl CA, Pilliod DS, Sheridan PP, Williams CF, Peterson CR, Bury R. Saprolegniaceae identified on amphibian eggs throughout the Pacific Northwest, USA, by internal transcribed spacer sequences and phylogenetic analysis. *Mycologia* 100:171-180.

- 2007 Adams MJ, Galvan S, Reinitz D, Cole RA, Pyare S, Hahr M, Govindarajulu P. Incidence of the fungus *Batrachochytrium dendrobatidis* in amphibian populations along the northwest coast of North America. *Herpetological Review* 38: *in press*.
- 2007 Adams MJ, Pearl CA. Problems and opportunities managing invasive Bullfrogs: is there any hope? *In*: Gherardi, F ed. *Biological invaders in inland waters: Profiles, distribution, and threats*. Springer, Dordrecht, The Netherlands.
- 2007 Pearl CA, Bull EL, Green DE, Bowerman J, Adams MJ, Hyatt A, Wenthe WH. Occurrence of the amphibian pathogen *Batrachochytrium dendrobatidis* in the Pacific Northwest. *Journal of Herpetology* 41:145-149.
- 2007 Pearl CA, Adams MJ, Wenthe WH. Characteristics of Columbia spotted frog (*Rana luteiventris*) oviposition sites in northeastern Oregon. *Western North American Naturalist* 67:86-91.
- 2007 Wang Y, Guo Z., Pearl CA, Li Y. Body size affects the predatory interactions between introduced American Bullfrogs (*Rana catesbeiana*) and native anurans in China: an experimental study. *Journal of Herpetology* 41:514-520.
- 2006 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. Taxonomic variation in oviposition by tailed frogs (*Ascaphus* spp.). *Northwestern Naturalist* 87:87-97.
- 2006 Pearl CA, Bowerman J. Observations of rapid colonization of constructed ponds by western toads (*Bufo boreas*) in Oregon, USA. *Western North American Naturalist* 66:397-401.
- 2006 Pearl CA. *Taricha granulosa* (Rough skin newt). Summer habitat and aggregation. *Herpetological Review* 37:71-72.
- 2005 Wu Z, Li Y, Wang Y, Adams MJ. Diet of introduced bullfrogs (*Rana catesbeiana*): predation on and diet overlap with native frogs on Daishan Island, China. *Journal of Herpetology* 39:668-674.
- 2005 Muths E, Jung RE, Bailey LL, Adams MJ, Corn PS, Dodd CK Jr, Fellers GM, Sadinski WJ, Schwalbe CR, Walls SC, Fisher RN, Gallant AL, Battaglin WA, Green DE. The U.S. Department of Interior's Amphibian Research and Monitoring Initiative (ARMI): A Successful Start to a National Program. *Applied Herpetology* 2:355-371.
- 2005 Bailey L, Adams M. Occupancy models to study wildlife. USGS Fact Sheet 2005-3096.
- 2005 Adams MJ, Hossack BR, Knapp RA, Corn PS, Diamond S, Trenham P, Fagre D. Distribution patterns of lentic-breeding amphibians in relation to ultraviolet radiation exposure in western North America. *Ecosystems* 8:488-500.
- 2005 Galvan SK, Adams MJ, Samora B, Holmes RE, Stonum S, Happe PJ, Glesne RS, and Rawhouser A. North Coast and Cascades Network Consolidated Amphibian Database and Mapping Project, Final Report. United States Geological Survey, Forest and Rangeland Ecosystem Science Center. 67 pp.
- 2005 Pearl CA, Green DE. *Rana catesbeiana* (American Bullfrog). Chytridiomycosis. *Herpetological Review* 36:305-306.
- 2005 Diamond SA, Trenham PC, Adams MJ, Hossack BR, Knapp RA, Stark SL, Bradford D, Corn PS, Czarnowski K, Brooks PD, Fagre D, Breen B, Detenbeck NE, Tonnessen K. Estimated ultraviolet radiation doses in wetlands in six National Parks. *Ecosystems* 8:462-477.
- 2005 Pearl CA, Adams MJ, Bury RB, Leuthold N. Amphibian occurrence and aquatic invaders in a changing landscape: implications for wetland mitigation in the Willamette Valley, Oregon. *Wetlands* 25:76-88.
- 2005 Corn PS, Muths E, Adams MJ, Dodd CK Jr. The US Geological Survey's Amphibian Research and Monitoring Initiative. *Alytes* 23:65-71.
- 2005 Wenthe WH, Adams MJ, Pearl CA. Evidence of decline for *Bufo boreas* and *Rana luteiventris* in and around the northern Great Basin, western USA. *Alytes* 23:95-108.
- 2005 Adams MJ, Pearl CA. Tailed frog, *Ascaphus truei*. Pp 382-384 *In*: Lannoo MJ, editor. *The Conservation Status of United States Species. Volume 2: Species Accounts*. University of California Press, Berkeley, California, USA.

- 2005 Adams MJ. Tailed frog, *Ascaphus montanus*. P 382 In: Lannoo MJ, editor. The Conservation Status of United States Species. Volume 2: Species Accounts. University of California Press, Berkeley, California, USA.
- 2005 Pearl CA, Adams MJ. Cascades frog, *Rana cascadae*. Pp 538-540 In: Lannoo MJ, editor. The Conservation Status of United States Species. Volume 2: Species Accounts. University of California Press, Berkeley, California, USA.
- 2005 Pearl CA. *Rana aurora*, Northern red-legged frog. Pp. 528-530, in Lannoo, M. J. (Ed.), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.
- 2005 Pearl CA, Hayes MP. *Rana pretiosa*, Oregon spotted frog. Pp. 577-580, in Lannoo, M. J. (Ed.), Amphibian Declines: The Conservation Status of United States Species. University of California Press, Berkeley, CA.
- 2005 Corn PS, Adams MJ, Battaglin WA, Gallant AL, James DL, Knutson M, Langtimm CA, Sauer JR. Amphibian research and monitoring initiative: concepts and implementation. US Geological Survey Scientific Investigations Report 2005-5015, 23 p.
- 2005 Hoffman RL, Tyler TJ, Larson GL, Adams MJ, Wentz W, Galvan S. Sampling protocol for monitoring abiotic and biotic characteristics of mountain ponds and lakes. U.S. Geological Survey Techniques and Methods 2-A2, 90 p.
- 2005 Pearl CA, Bowerman J, Knight D. Feeding behavior and aquatic habitat use by Oregon spotted frogs (*Rana pretiosa*) in central Oregon. Northwestern Naturalist 86:36-38.
- 2005 Pearl CA, Hayes MP, Haycock R, Engler JD, Bowerman J. Interspecific amplexus between western North American ranid frogs and the introduced American Bullfrog (*Rana catesbeiana*): An hypothesis concerning breeding interference. American Midland Naturalist 154:126-134.
- 2005 Rombough CJ, Pearl CA. *Rana pretiosa* (Oregon spotted frog). Aggregation and Habitat Use. Herpetological Review 36:307-308.
- 2004 Palen WJ, Schindler DE, Adams MJ, Pearl CA, Bury RB, Diamond SA. Optical characteristics of natural waters protect amphibians from UV-B in the US Pacific Northwest: a reply. Ecology 85:1754-1759.
- 2004 Pearl CA, Adams MJ, Bury RB, McCreary B. Asymmetrical effects of non-native bullfrogs (*Rana catesbeiana*) on native ranid frogs in Oregon, USA. Copeia 2004:11-20.
- 2004 Adams MJ, Pearl CA, Bury RB. Wetland Management for Amphibians in the Willamette Valley. USGS Fact Sheet FS 2004-3039.
- 2004 Jordan DJ, Rombough CJ, Pearl CA, and McCreary B. Cannibalism and predation by western toad (*Bufo boreas*) larvae in Oregon, USA. Western North American Naturalist 64:403-405.
- 2003 Adams MJ. The Amphibian Research and Monitoring Initiative in the Pacific Northwest. USGS Fact Sheet. FS-0020-03.
- 2003 Adams MJ. Tailed frogs. In: Harris T, technical editor, Reptiles and Amphibians. Pp 1174-1193. Tarrytown, NY: Marshall Cavendish Corporation.
- 2003 Adams MJ, Pearl CA, Bury RB. Indirect facilitation of an anuran invasion by non-native fishes. Ecology Letters 6:343-351.
- 2003 Pearl CA, Adams MJ, Schuytema GS, Nebeker AV. Behavioral responses of anuran larvae to chemical cues of native and introduced predators in the Pacific Northwestern United States. Journal of Herpetology 37:572-576.
- 2002 Palen WJ, Schindler DE, Adams MJ, Pearl CA, Bury RB, Diamond SA. Optical characteristics of natural waters can protect amphibian populations from UV-B in the US Pacific Northwest. Ecology 83:2951-2957.
- 2002 Adams MJ, Bury RB. The endemic headwater stream amphibians of the American Northwest: associations with environmental gradients in a large forested preserve. Global Ecology and Biogeography 11:169-178.
- 2001 Adams MJ, Schindler DE, Bury RB. Association of amphibians with attenuation of ultraviolet-b radiation in montane ponds. Oecologia 128:519-525.
- 2001 Bury B, Loafman P, Rofkar D, Mike KI. Clutch sizes and nests of tailed frogs from the Olympic Peninsula, Washington. Northwest Science 75:419-422.

- 2000 Adams MJ. Pond permanence and the effects of exotic vertebrates on anurans. *Ecological Applications* 10:559-568.
- 2000 Adams MJ, Bury RB. Amphibians of Olympic National Park. Fact Sheet 098-00, USGS, Corvallis, Oregon.

Presentations

- Feb 2010 Contributed Paper. Leuthold N, Adams MJ, Hayes JP. Short-term response of Pacific Giant Salamanders to timber management in southwestern Oregon. Annual Meeting of Society for Northwestern Vertebrate Biology, Medford, Oregon, USA.
- Feb 2010 Invited Paper. Adams MJ. Does the probability of local extinction for the northern red-legged frog relate to introduced fish or bullfrogs? Annual Meeting of the Oregon Chapter of the Wildlife Society, Bend, Oregon, USA.
- Feb 2010 Contributed Paper. Pearl CA, Adams MJ. Oregon Spotted Frogs (*Rana pretiosa*) in the Klamath Basin: status, threats, and local restoration. Klamath River Basin Science Conference. Medford, Oregon, USA.
- Oct 2009 Invited Seminar. Adams MJ. The use of patch occupancy models to study patterns of occurrence in ecology. Portland State University Environmental Sciences Seminar Series, Portland, Oregon, USA.
- Jul 2009 Contributed Paper. Leuthold N, Adams M, Hayes J. Short-term response of stream amphibians to forest management in a second growth forest. Joint Meeting for Ichthyology and Herpetology, Portland, Oregon, USA.
- May 2009 Contributed Paper. Johnson SL, Bilby RE, Li J, Dunham J, Adams M. Trask River Watershed Study: New food web studies of forest-stream interactions in a managed landscape. Annual Meeting of North American Benthological Society. Grand Rapid, Michigan, USA.
- Feb 2009 Contributed Paper. Jenkins KJ, Chelgren ND, Sager KA, Happe PJ, Adams MJ, Perakis SS. Response of riparian wildlife communities to restoration of anadromous fish in the Elwha River ecosystem. Annual Meeting of the George Wright Society, Portland, Oregon, USA.
- Oct 2008. Invited Seminar. Adams MJ. Living with invasive species: bullfrogs and other species that we can't get rid of. University of Washington, Wildlife Seminar Series. Seattle, WA, USA.
- Oct 2008. Invited Paper. Adams MJ, Leuthold N, Chelgren N. The impact of forest practices on stream amphibians: preliminary results from Hinkle Creek and future investigations at the Trask Paired Watershed Study. Conference on paired watershed studies. Corvallis, OR, USA.
- Aug 2008. Invited Paper. Adams MJ. The US Geological Survey's Amphibian Research and Monitoring Initiative. Annual meeting of the Natural Resources Information Council. Eugene, OR, USA.
- Apr 2008. Invited Seminar. Adams MJ. The role of bullfrogs in amphibian decline. Monthly Meeting of the Mary's River Watershed Council. Philomath, OR, USA.
- Mar 2008. Invited Paper. Adams MJ. Amphibian declines. Rangewide Meeting for Columbia Spotted Frog Recovery. Boise, ID, USA.
- Feb 2008. Invited Paper. Adams MJ. Beaver and amphibians: inference and innuendo. Annual Meeting of the Oregon Chapter of the Wildlife Society, Gleneden Beach, OR, USA.
- Nov 2007. Invited Paper. Adams MJ. Understanding spatial and temporal patterns of a pathogen in wild populations. International Workshop on Chytridiomycosis. Tempe, AZ, USA.
- Jul 2007. Contributed Paper. Adams MJ, Cole RA, Rachowicz LJ. Occurrence and prevalence of the pathogen, *Batrachochytrium dendrobatidis*, in Oregon and Northern California anurans. Annual Meeting of the American Society for Ichthyologists and Herpetologists, Saint Louis, MO, USA.
- Jul 2007. Bartelt PE, Klaver RW, Porter WP, Pilliod DS, Peterson CR, Gallant AL. Amphibian physiology and landscape permeability: Modeling thermal landscapes to predict amphibian movements. International Association for Landscape Ecology World Congress, Wageningen, The Netherlands.

- Apr 2007. Invited Paper. Adams MJ, Cole RA, Rachowicz LJ. Occurrence of the pathogen, *Batrachochytrium dendrobatidis*, in Oregon and Northern California anurans. Annual Meeting of the Oregon Chapter of the Wildlife Society, Pendleton, Oregon, USA.
- Apr 2007. Pearl CA, Adams MJ. Oregon spotted frog (*Rana pretiosa*) status and potential stressors in Oregon. Annual Meeting of the Oregon Chapter of the Wildlife Society, Pendleton, Oregon, USA
- Feb 2007. Contributed Paper. Chelgren ND, Pearl CA, Adams MJ, Bowerman J. Oregon spotted frog movement and demography at Dilman Meadow: 5 years of population change following translocation. Annual Meeting of the Society for Northwestern Vertebrate Biology, Victoria, British Columbia, Canada.
- Dec 2006. Invited Paper. Adams MJ. The concept of coexistence as it applies to invasive species management. USGS Invasive Species Program Workshop, Albuquerque, NM, USA.
- Mar 2006. Invited Paper. Adams MJ, Pearl CA. Bullfrog management revisited. Symposium honoring Dr. R. Bruce Bury, Annual Meeting of the Society for Northwestern Vertebrate Biology, Olympia, WA, USA.
- Feb 2006. Invited Lecture. Adams MJ. Amphibian and reptile issues. Wildlife Enumeration Workshop, Oregon Chapter of The Wildlife Society Annual Meeting, Newport, OR, USA.
- Feb 2006. Invited Keynote Paper. Adams MJ. Monitoring the occupancy of ponds by frogs in relation to stressors: an ARMI example. Second All-Alaska Amphibian Conference, Juneau, AK, USA.
- Feb 2006. Contributed Paper. Chelgren ND, Adams MJ, Bailey LL. Terrestrial salamander response to the 2003 Clark Fire, Willamette National Forest, Oregon. Oregon Chapter of The Wildlife Society Annual Meeting, Newport, OR, USA.
- May 2005. Invited Paper. Adams MJ. Living with bullfrogs: can we manage for coexistence? Biological Invasions of Inland Waters: An International Workshop. Florence, Italy.
- Mar 2005. Invited Seminar. Adams MJ. Living with bullfrogs: attributes of coexistence. US Fish and Wildlife Service Region 1 Headquarters, Portland, OR, USA.
- Feb 2005. Invited Paper. Adams MJ. Managing non-native bullfrogs in the western US: is there any hope? In Workshop "Invasive species management: assessing and addressing threats to Oregon's wildlife and habitats." Corvallis, OR, USA.
- Feb 2005. Contributed Paper. Pearl CA, Bowerman J, Ackley S, Bury RB. Translocation of Oregon spotted frogs (*Rana pretiosa*) near Wickiup Reservoir. Soc. NW Vertebrate Biology/The Wildlife Soc, Oregon Chapter Joint Meeting. Corvallis, Oregon.
- Nov 2004. Invited Seminar. Adams MJ. Quantifying change in a diverse resource: the ARMI approach to amphibian monitoring. Fisheries and Wildlife Seminar, Oregon State University, Corvallis, OR, USA.
- Oct 2004. Presented Poster. Pyare S, Carstensen R, Christiansen B, Adams MJ. A multi-scale approach to monitoring site-selection for western toads in Glacier Bay. Alaska Science Conference, Juneau, AK, USA.
- Oct 2004. Presented Paper. Skaugset A, Gresswell R, Li J, Adams M, Cromack K. Cumulative environmental effects of contemporary forest management activities in headwater basins of western Oregon. Annual Meeting of the American Institute of Hydrology, Las Vegas, NV, USA.
- May 2004. Invited Keynote Speaker. Adams MJ. Quantifying change in a diverse resource: the ARMI approach to amphibian monitoring. Annual Meeting of the American Society of Ichthyologists and Herpetologists, Norman, OK, USA.
- May 2004. Invited Paper. Wente WE, Adams MJ, Pearl CA. Evidence of decline in *Bufo boreas* and *Rana luteiventris* in the vicinity of the northern Great Basin. Annual Meeting of the American Society of Ichthyologists and Herpetologists, Norman, OK, USA.
- May 2004. Invited Paper. Pearl CA, Adams MJ, Bury RB, McCreary B. Asymmetrical effects of introduced bullfrogs (*Rana catesbeiana*) on native ranid frogs in Oregon, USA. Annual Meeting of the American Society of Ichthyologists and Herpetologists, Norman, OK, USA.
- May 2004. Invited Paper. Liu C, Heppell SS, Li HW, Adams MJ, Pearl CA, Jorgensen J. Models to qualify the impacts of exotic species on native red-legged frogs (*Rana aurora*) in Willamette Valley, Oregon. Annual Meeting of the American Society of Ichthyologists and Herpetologists, Norman, OK, USA.

- Feb 2004. Invited Featured Speaker. Adams MJ. The US Department of the Interior's Amphibian Research and Monitoring Initiative. First Alaska Conference on Amphibians, Juneau, Alaska, USA.
- Nov 2003. Contributed Poster. Adams MJ, Wenthe WH, Graham TB, Bury RB, Anderson CW, Galvan SK, Pearl CA. ARMI: Amphibian research and monitoring initiative in the Pacific northwest region. Annual Meeting of the Society of Environmental Toxicology and Chemistry, Austin, Texas, USA.
- Nov 2003. Contributed poster. Graham TB, Willbrand S, Reilly J, Wakefield G. Implementation of the amphibian research and monitoring initiative on the Colorado Plateau: pitfalls along the way to selecting and defining amphibian habitat. 7th Biennial Conference on Research in the Colorado Plateau Parks, Northern Arizona University, Flagstaff, AZ.
- Nov 2003. Contributed Poster. Rostad CE, Anderson CW, Wenthe WH, Pearl CA, Adams MJ, Noyes T. Steroidal hormones at cattle grazing sites in eastern Oregon. Annual Meeting of the Society of Environmental Toxicology and Chemistry, Austin, Texas, USA.
- Mar 2003. Invited Paper. Pearl CA, Adams MJ, Leuthold N, Bury RB. Amphibian occurrence and aquatic invaders in a changing landscape: implications for wetland mitigation in the Willamette Valley, Oregon. Annual Meeting of the Society for Northwestern Vertebrate Biology, Arcata, California, USA.
- Feb 2003. Invited Paper. Palen WJ, Schindler DE, Adams MJ. Landscape variation in amphibian sensitivity to UV-B radiation. Winter meeting of the American Society of Limnologists and Oceanographers, Salt Lake City, Utah, USA.
- Jan 2002. Invited Seminar. Adams MJ. Invading the swamp: are introduced fish and bullfrogs in cahoots? Oregon State University, Department of Forest Science.
- April 2002. Contributed paper. Wenthe WH, Adams MJ, Pearl CA, Bury RB. Amphibian Research and Monitoring Initiative (ARMI): 2001 Eastern Oregon Field Season Review. Annual Meeting of the Society for Northwestern Vertebrate Biology.
- April 2002. Contributed paper. Adams MJ, Hossack BR, Knapp RA, Corn PS, Diamond S, Trenham P, Fagre D. Distribution patterns of lentic breeding amphibians in relation to ultraviolet-b radiation exposure in western North America. Annual Meeting of the Society for Northwestern Vertebrate Biology.
- July 2002. Invited paper. Adams MJ, Pearl CA, Bury RB, Nebeker A. Indirect facilitation of bullfrog invasion by non-native fishes. Annual Meeting of the American Society of Ichthyologists and Herpetologists, Kansas City, Missouri, USA.
- Oct 2002. Invited paper. Adams MJ, Pearl CA, Bury RB, Nebeker A. Indirect facilitation of bullfrog invasion by non-native fishes. Annual Meeting of The Wildlife Society, Bismarck, North Dakota, USA.
- Nov 2002. Invited seminar. Adams MJ, Pearl CA. Novel predators and prey behavior: non-intuitive effects of non-native fish and bullfrogs. University of Washington Wildlife Seminar Series.