The U.S. Geological Survey Amphibian Research and Monitoring Initiative — 2012 Annual Update

Objective

The Amphibian Research and Monitoring Initiative assists Department of Interior (DOI) resource management agencies with information needs related to amphibian conservation. ARMI's work includes research on threats, method development, and monitoring designed to address management needs at multiple spatial scales.

News

Welcome to the 2012 ARMI Annual Update, which provides highlights and significant milestones of this innovative program. ARMI is uniquely qualified to provide research and monitoring results that are scalable from local to national levels and are useful to resource managers. ARMI has produced more than 420 peer-reviewed publications since its inception. Some of those publications are highlighted in this fact sheet. Please visit our website (http://armi.usgs.gov) for additional information on ARMI products, to find summaries of research topics, to search for ARMI activities in your area, or to obtain amphibian photographs. This year, we introduced a new feature on the ARMI website called "Trend Data" that provides occupancy and abundance estimates at the project level (http://armi.usgs.gov/projects/estimates_datasets.php). Data can be accessed in tabular format or plotted via an interactive map browser.

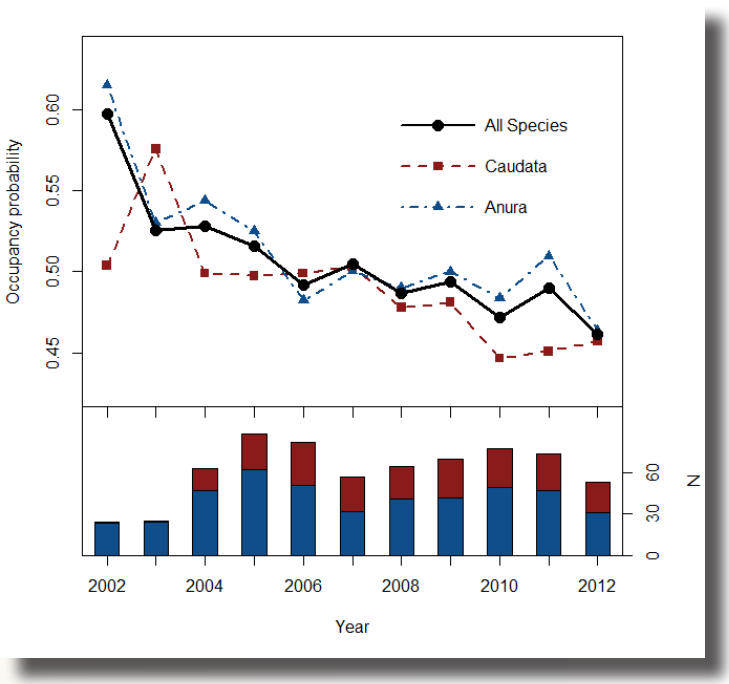
ARMI had an exciting year with several events that took us back to our inception. ARMI sponsored a symposium at the 2012 World Congress of Herpetology in Vancouver, Canada, entitled "Amphibian monitoring across the U.S.: Tracking declining populations in diverse habitats and unique assemblages". The World Congress is an important venue for exploring new ideas and developing the kinds of partnerships necessary to carry out challenging research and conservation.

Two of our ARMI Regional Principal Investigators (PIs) from the Southwest Region, retired. As one of the founders of ARMI, Gary Fellers (Point Reyes, CA) participated in the early working groups that explored options for responding to the global amphibian extinction crisis. Gary became a liaison between the scientific community and politicians. Gary kept attention focused on the need for scientific rigor in a government program, with accurate and reliable information provided to DOI and State partners. Cecil Schwalbe came to ARMI after a long career as the Herpetologist for the state of Arizona. Cecil retained his appreciation for the role of stakeholders in shaping the land, and the relationships he nurtured among governmental and nongovernmental partners yielded significant dividends for the conservation of desert amphibians.

ARMI biometrics post-doc David Miller accepted a position as Assistant Professor of Wildlife Population Ecology at Pennsylvania State University. While with ARMI, David was instrumental in developing several statistical models and quantifying the effects that different types of detection error (e.g., false positive) can have on population and occupancy estimates.

National Summary Statistics

ARMI consists of individual projects with their own objectives, but each project tracks a primary amphibian metric across the country. Apex monitoring sites track abundance and Mid-Level monitoring areas track occupancy. Abundance is the number of amphibians in a population or the number of egg



Annual estimates of the probability of site occupancy for all amphibians (black line) and for Caudata (salamanders; red line) and Anura (frogs and toads; blue line) separately at ARMI Mid-Level monitoring areas. The bar graph shows the number of Mid-Level occupancy estimates each year.

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masses produced. Occupancy is the probability that a site is occupied by a given species and ARMI considers this to be the most meaningful metric of amphibian status. Though the monitoring projects that produce these metrics each have their own methods and goals, we are able to compare trends among sites and over time.

As of 2012, ARMI had accumulated 679 estimates of occupancy for 114 time series (a time series is a temporal sequence of occupancy estimates for a species at a monitoring area). Each of these estimates applies to a defined area of inference that typically covers tens to hundreds of potential amphibian habitat units. Each project requires multiple surveys of a subset of units within the area of inference so that the probability of detecting a species that is present can be incorporated into an estimate of occupancy. ARMI has 34 monitoring areas across the United States that produce occupancy estimates for 50 species of amphibian. Time series range from 2 to 10 years. These data represent the most comprehensive and quantitative data on amphibian trends in the United States.

Although the primary objective of ARMI is to provide information for DOI resource managers at a local scale, ARMI data are a unique resource in the ongoing global assessment of amphibian decline. ARMI estimates that the probability of site occupancy for the amphibians monitored has declined 2.9% per year (95% confidence interval = -5.2% – -0.6%) since 2002.

The species and places monitored were selected for reasons related to local objectives and do not necessarily represent other species and places. In some cases, species were selected for study because of conservation concerns, but ARMI scientists often monitor a suite of species that occur in a particular habitat. We note that ARMI began after some of the severe declines in the United States are thought to have occurred.

Boreal Toad. Photo by B. Hossack, U.S. Geological Survey.

Project Updates

Quantifying the Benefit of Wetland Conservation Programs

The U.S. Farm Bill legislation has funded several conservation programs administered by the Natural Resources Conservation Service (NRCS), including the Wetlands Reserve Program (WRP). The WRP is a voluntary program that provides financial incentives and technical assistance to landowners who restore wetlands on their property. Until recently, few studies have quantified the value of WRP lands to wildlife. As part of the NRCS Conservation Effects Assessment Program, ARMI scientists compared species richness and occurrence probability of 11 species of frogs and toads at a series of WRP sites to nearby agricultural sites in the Delta Region of northwest Mississippi. Estimates from a multi-species, hierarchical Bayesian model that accounted for imperfect detection revealed that 9 of the 11 species were more likely to occur at WRP sites compared with agriculture sites, resulting in greater community richness in the restored wetlands. Restoration of more permanent hydrology at the WRP sites appeared to be an important driver of increased community richness. These results indicate that WRP sites serve as important amphibian habitat, and there is a pool of species available in the landscape from which the sites may be colonized after restoration.

Waddle, J. H., B. M. Glorioso, and S. P. Faulkner. 2013. A quantitative assessment of the conservation benefits of the Wetlands Reserve Program to amphibians. Restoration Ecology 21: 200-206.

Long-Term Monitoring Data Used to Measure Responses to Rare Events

Climate change is expected to increase the frequency and severity of many disturbances, including large wildfires. Amphibians and other moisture-sensitive species may be particularly vulnerable to these modified disturbance regimes because large wildfires often occur during extended droughts, potentially compounding environmental threats. However, there is still limited understanding of the effects of wildfire on amphibians in forests with long fire-return intervals (e.g., >100 years between wildfires). It is difficult to measure effects of infrequent events and several years of data are often needed to capture the full range of responses. Using data collected since 1999, ARMI researchers measured pre- and post-fire responses of 3 amphibian species to 6 wildfires that burned between 1988 and 2003 in Glacier National Park, Montana. For 2 species, occupancy was not affected during the first 6 years after wildfire. But 7–21 years after wildfire, occupancy for both species decreased ≥25% in areas where the majority of forest burned. In contrast, occupancy of a 3rd species tripled in the 3 years after low-elevation forests burned, but then declined gradually during subsequent years. These results show that measuring the magnitude of habitat change (i.e., burn severity) and allowing for time lags is critical to understanding population dynamics of amphibians after large disturbances. These results also increase our understanding of the potential threat of increases in wildfire frequency or severity to amphibians.

Hossack, B. R., W. H. Lowe, and P. S. Corn. 2013. Rapid increases and time-lagged declines in amphibian occupancy after wildfire. Conservation Biology 27: 219-228.

Did We Get it Right This Time?

To determine optimal conservation strategies, it is essential to understand species-habitat relationships and how species use of habitat is related to environmental change. Moreover, models designed to guide management must provide clear insight into the accuracy, reliability, and inherent uncertainty of predictions. The conservation of amphibian communities presents a particularly formidable challenge to resource managers because populations respond to both local and broad-scale factors (which may differ among species that share the same habitat), potentially limiting management actions available within protected areas. Using five years of monitoring data from the Chesapeake and Ohio Canal National Historical Park, Maryland, ARMI researchers developed 4 multi-species, hierarchical occupancy models to determine which factors (wetland habitat characteristics, annual trend effects, spring/summer precipitation, and previous wetland use) were most important for predicting future habitat use. Wetland hydroperiod (the length of time that a wetland holds water) and the occurrence state in the prior year were generally the most important factors in determining occupancy. The model with only habitat covariates predicted species occurrences well; however, knowledge of wetland use in the previous year significantly improved predictive ability at the community level and for 2 of 12 species. Based on the results from this analysis, managers could use a habit-only model to make reasonable predictions about the status of amphibian richness at all wetlands in the park. This information could then be used to assess which wetlands might benefit most from management actions. These results demonstrate the utility of multi-species models for understanding which factors affect habitat use of an entire community, and provide an improved methodology that is helpful for quantifying the uncertainty in model predictions while explicitly accounting for detection biases.

Zipkin, E. F. , W. F. Fagan, and E. H. C. Grant. 2012. Did we get it right? Evaluating predictions of species' distribution while incorporating uncertainty. Ecological Applications 22: 1962–1972.

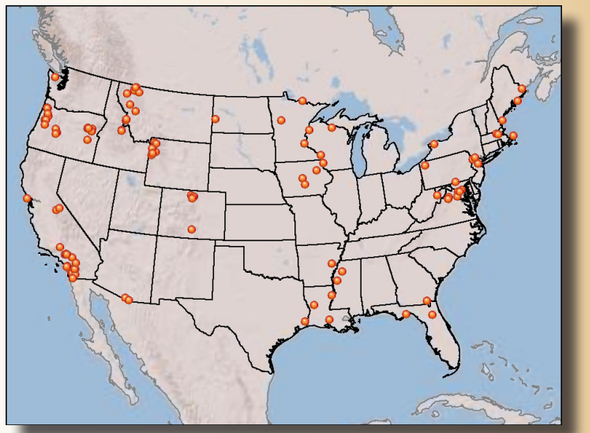
Using New Statistical Tools to Estimate Habitat Dynamics and Species Interactions Simultaneously

The processes that determine patterns of species occurrence and co-occurrence have long been a focus in ecology but have been difficult to address in dynamic systems. ARMI researchers in southern California were interested in how the federally endangered arroyo toad (Anaxyrus californicus) responded to a combination of fluctuating water levels and aquatic predators (e.g., American bullfrog, crayfish) in ephemeral streams. Occurrence data were collected from stream segments in 2 watersheds in southern California where streams were largely ephemeral and 1 watershed dominated by perennial streams. Occupancy of toads was higher in ephemeral habitats than in permanent habitats, likely because drying of streams caused local extinction of predators and allowed the terrestrial toads to colonize predator-free areas after they re-filled. This case study demonstrated that dynamic multi-state occupancy models provide a powerful tool for direct estimation of the processes that determine species–species and species–habitat interactions. This study also highlights the value of continued ARMI support for development of new statistical models.

Miller, D. A. W., C. S. Brehme, J. E. Hines, J. D. Nichols, and R. N. Fisher. 2012. Joint estimation of habitat dynamics and species interactions: disturbance reduces co-occurrence of non-native predators with an endangered toad. Journal of Animal Ecology 81: 1288-1297.

Simulating the Potential Effects of Climate Change on Amphibian Habitats

Climatic variability and its potential effects on amphibian habitats is a growing concern for wildlife managers. Detailed projections of future climatic conditions are needed to determine the potential effects of climate change on wetlands, streams, and aquatic habitats that are critical for amphibians. USGS scientists recently conducted a series of investigations to project hydrologic responses that could result from different greenhouse gas emission scenarios during the 21st Century. Outputs from downscaled global circulation models were used as input to calibrated distributed-parameter watershed models that produced watershed- and sub-watershed scale estimates of changes in temperature, precipitation, timing of runoff, and other hydrologic variables in 14 river basins across the USA. In regions with snowmelt-dominated hydrology, predictions for earlier snowmelt and increased evapotranspiration could cause several threats to aquatic habitats, including longer summer droughts, reduced soil moisture and wetland hydroperiods, and more wildfires. A companion study focused on Colorado indicated little expected change in total precipitation, but increasing temperatures will result in less snowpack and earlier runoff. This research



ARMI Apex and Mid-Level monitoring sites. Factors related to population dynamics are studied at Apex sites. Factors related to site occupancy dynamics are studied at Mid-Level sites.

demonstrates the utility of distributed-parameter watershed models for helping wildlife managers understand the potential effects of climate change on local areas or habitats within the landscapes they are tasked with protecting.

Battaglin, W.A., L.E. Hay, and S. Markstrom. 2011. Simulating the potential effects of climate change in two Colorado basins and at two Colorado ski areas. Earth Interactions 15(22): 1-23.

Background

ARMI resulted from the first multidisciplinary funding request in USGS and remains a leading example of what can be achieved by applying USGS's broad expertise and geographic scope to high priority resource problems. ARMI is a national research and monitoring program that is modular: it is composed of a series of monitoring projects, each designed to meet specific local objectives. These monitoring studies are carried out by 13 ecological and various water science centers, distributed across all regions of the lower 48 states. Each project complies with national guidelines, developed collaboratively among ARMI investigators, to facilitate broad synthesis at regional and national scales. This modular framework is novel for a national program and is a key feature that allows ARMI to partner with resource managers and meet their information needs. This modular framework also allows non-standardized methods to produce comparable data that can be scaled up across spatial scales. Since its initiation in 2000, ARMI has built an unprecedented national data set on amphibian occupancy and abundance. These data provide the only large-scale, quantitative information on amphibian trends in North America and have led to more than 420 peer-reviewed publications.

Although we have learned much since 2000, declines have not abated and interactions among threats to amphibians are complex. Destruction of habitat remains a primary cause of decline, but other factors such as emerging infectious disease and invasive species are also important. Amphibian decline is a problem of local, national, and international scope that can affect ecosystem function, diversity, and commerce. To stem or reverse these declines, DOI managers and other partners need scientifically sound information at local, regional, and national scales. ARMI's modular approach is specifically designed to meet these multi-scale needs. By working with land managers at a local level, ARMI investigators can design projects that address site-specific questions and use methods best suited to local conditions. ARMI's close relationship with on-the-ground managers also ensures that information needs are thoroughly understood, resulting in significant leveraging of funding and resources. By following ARMI guidelines for developing population parameter estimates, these diverse and locally-responsive investigations also support analyses of regional and national trends and other broad-scale questions of importance to conservation partners.

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Front page photographs: Anza Borrego Desert State Park, by C. Brown, U.S. Geological Survey; Green Frog, by B. Gratwicke, Creative Commons.

Back page photographs: Green treefrog, by H. Waddle, U.S. Geological Survey.

ARMI Principles

- Treat monitoring as research.
- Maintain the flexibility to tailor projects to local needs.
- Focus on statistically unbiased metrics that can be scaled up to achieve broader synthesis.

Frequently Asked Questions

Are amphibians really declining?
Yes, a large and growing body of evidence indicates that a significant proportion of the amphibian species are declining at an alarming rate. These declines are occurring in the United States and elsewhere around the world.

What alerted the natural resource community to global amphibian declines?
A combination of direct observations, estimates, and expert opinion were used to recognize and raise awareness of global amphibian declines. ARMI uses estimates of occupancy or abundance to assess continuing changes in the national status of amphibians.

Why are amphibians declining?
There is not one, single cause of amphibian declines. Instead, a combination of habitat loss, disease, invasive species, contaminants, and perhaps other threats have combined to create the current crisis.

Why should we care if amphibians are declining?
Amphibians play important roles in ecosystems, human health, and commerce. They have social value as symbols in some cultures, and they represent an ancient source of biodiversity.

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