CLIMATE CHANGE RESOURCE CENTER

Amphibians and Climate Change

Preparers

Deanna H. Olson, Pacific Northwest Research Station; Daniel Saenz, Southern Research Station

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Issues

Several factors contribute to the vulnerability of amphibians to the projected effects of climate change. First consider that for over 20 years, amphibians have been globally recognized as declining (1). Today, they are among the leading taxonomic groups threatened with losses: about 1/3 of amphibian species are already at risk of extinction (2, 3). Leading threat factors include habitat loss, disease, invasive species, overexploitation, and chemical pollution. Next, consider their basic biology. Amphibians have been heralded as Canaries in the Coal Mine, being sentinels of a host of environmental changes due to their biphasic life style with life stages relying on both aquatic and terrestrial systems, their moist permeable skin which is a sensitive respiratory organ, and their central position in food webs. The scenario becomes even more complex when multiple threats affect single populations and the synergistic effects of threats together may become more potent than the simple sum of those parts. Now, adding the effects of climate change to this cocktail of multiple threats and climate-sensitive life history modes is worrisome indeed.

Numerous researchers have considered the adverse effects of climate change on amphibians and found differing results (4-13) suggesting that risks vary among taxa. Dispersal-limited or rare species may have restricted movements and may not be able to shift their distribution to accommodate changes in the locations of suitable habitat. In contrast, species with continental distributions may have innate resiliency to a broad swath of conditions, and have better adaptive capacity to survive as a whole. Amphibian species with narrow tolerances for temperature and moisture regimes may be at heightened risk. Amphibians that rely on certain habitat types may be at most risk, for example those found in ephemeral ponds and streams which may dry before the annual reproductive cycle is complete. Regions projected to have increasing fluctuations in climate conditions may experience reproductive "bust" years, or episodic mass mortality (14).

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Likely Changes

Knowing that climate change predictions vary considerably with geographic locations, that there is uncertainty tied to all climate change models, and amphibians are an extremely diverse taxon -a single or simple answer of how amphibians are likely to respond to climate change is not possible. Several types of likely changes may prove to be lethal to amphibians: altered hydroperiods; altered seasons and phenology (cyclical timing of events); increased incidence of severe storms and storm surge; rise in sea level; fluctuating weather conditions; and warmer, drier conditions (e.g., 14-24).

Hydroperiod refers to the timing of water availability. Water retention in streams and ponds is particularly important for amphibians breeding in temporary, ephemeral, or vernal ponds and intermittent or discontinuously flowing streams. Many taxa are already experiencing occasional early drying of their habitats, with mass mortality of eggs, tadpoles, and metamorphosing animals resulting (25). Some of these habitats are also important foraging habitats or dispersal ‘stepping stones’, so altered hydroperiods can have negative effects outside of reproductive losses. Another side effect of changed hydroperiod could be increased exposure to predators. For example, if shorelines recede then amphibian refugia may be lost and fish, bird or mammal predators may gain access to newly exposed amphibian prey.

Phenology refers to the timing of life cycle events such as breeding and overwintering. Each plant and animal species has its own phenological patterns associated with local climatic conditions. Climate change may result in shifts in phenology, especially for species that breed early or late in the season. A shift to earlier breeding may leave amphibians exposed to fluctuating weather conditions. For example, a warm spell in late winter followed by a cold storm after breeding can freeze animals. A deep freeze may penetrate below the ground surface to affect animals emerging in spring, or overwintering hibernacula in winter. Also, survival of annual recruits may be tied to their size at metamorphosis, which may depend upon when breeding occurs. Furthermore, if the synchrony of communities (the timing of breeding or other activities) becomes offset, there may be altered interactions with predator and prey species or increased exposure to disease and invasive species. Lastly, generally warmer, drier conditions can cause moist microhabitats to become too dry and unsuitable for native amphibians. This may especially affect leaf litter or other refugia on the ground surface.

Options for Management

A recent paper on "Engineering a future for amphibians with climate change" (14, 26, 27) discusses a variety of adaptation management approaches. These approaches are discussed briefly below, and focus on tools that we may use to safeguard habitat conditions for vulnerable amphibian populations.

Manipulation of hydroperiod or moisture regimes at sites is a dominant tool in the land manager’s repertoire to mitigate the effects of climate change on any wildlife group. This can be implemented by a variety of methods, including: irrigation, site excavation, vegetation management, riparian buffer creation, down wood recruitment, and litter supplementation. Novel engineered approaches include installation of solar-powered water pumps to retain water levels of ponds, and installation of sprinkler systems to retain surface moisture. Consideration of climate during landscape management planning may result in incorporation of hill-shaded refugia in protected habitat areas (29) and designation of linkage areas for connectivity among habitats (30, 31). Using logs as dispersal conduits, and forest thinning to ameliorate dry conditions are being trialed in case studies. A new "hot topic" of research is investigating the effects of alternative forest management practices on microclimate, and specifically tying these effects to certain metrics of biodiversity such as moisture sensitive amphibians (32). Policies directed at vulnerable site protection, such as riparian reserves (14), are likely the most pro-active management option that has multiple-site implications.

If stop-gap measures are needed for rare species faced with extinction, the more costly methods of Reintroduction, Relocation, Translocation, and Headstarting (RRTH) may be considered. In the United States, numerous RRTH projects are underway for amphibians and reptiles (28). Captive breeding and RRTH programs are also managed by Zoos and Aquariums, with the international program Amphibian Ark being the most notable.

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Related Links

Climate change and herpetofauna resource page, sponsored by Partners in Amphibian and Reptile Conservation: http://parcplace.org/parcplace/resources/new-climate-change-and-herps.html

Brochure on climate change and amphibians and reptiles. Available at: http://parcplace.org/images/stories/ClimateChangeFlyer.pdf

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Compilation of Relocation, Reintroduction, Translocation, and Headstarting (RRTH) projects for herpetofauna. Available at: http://parcplace.org/news-a-events/242-rrth.html

Research

Ongoing research on amphibians by US Forest Service scientists includes the following topics that relate to climate and climate change:

Climate Change and Herpetofauna
Climate change is expected to affect amphibians through a number of direct and indirect mechanisms. This project focuses on examining several of these mechanisms, as well as potential management responses, including:

- "Shrinking heads hypothesis" - How do forested headwater streams respond to low water years? Do riparian buffers mitigate shrinking heads effects?
- Over-ridge connectivity designs for forested amphibians.
- Climate associations of the amphibian chytrid fungus.
- Long-term monitoring of anuran breeding dates in the Cascade Range.

Contact: Dede Olson

Climate and breeding phenology of anuran species in Texas
Changing weather patterns from global climate change could be a contributing factor in declining frog populations, particularly for species that rely on ephemeral water sources, like some of those in eastern Texas. Scientists in Nacogdoches, TX are currently studying the effects of rainfall and temperature on the breeding activities of 13 different species of frogs in eastern Texas. Information from the research will make it possible to predict potential effects of a changing climate on frog populations.
Contact: Dan Saenz

Impacts of year-year variations of precipitation (snowpack and rainfall) on amphibian recruitment and survival
This study explores the link between the changes in water availability -- including complete pond drying -- and the abundance and recruitment of mountain yellow-legged frog in Dusy Basin , Kings Canyon National Park , California , USA . We propose using the low-snowpack years (1999, 2002, 2004) as comparative case studies to predict future effects of climate change on aquatic habitat availability and amphibian abundance and survival.
Contact: Kathleen Matthews

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