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Reptiles and Climate Change [1]

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Synthesis:

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An archived version [4] of this topic paper is available.

Issues

Many reptiles are highly sensitive to the altered temperatures that may result from climate change due to their ectothermy which requires that they rely on ambient environmental temperatures to maintain critical physiological processes. Due to the variety of snakes, lizards, crocodilians, and turtles in our world (traditionally classified as reptiles), and because climate change data and projections vary with location, it will be important to consider each species and location separately when considering the potential effects of altered climate on these animals.

In temperate zones, lizards are thought to be highly vulnerable to climate change (1-7). Their reproduction is closely tied to narrow windows of time in the spring and summer when suitable temperature and moisture regimes are available for critical natural history activities, such as foraging and mating. Altered weather conditions during these seasons may result in frequently recurring "bust" years of reproductive failure. Other climate effects on lizard survival include mortality associated with warm spells in winter (8), interacting effects of altered vegetation communities, fire regimes and invasive species (9), and potentially disease (10).
Snakes are very closely related to lizards, and these effects may hold true for them as well. Just as with lizards, new studies illustrate species differences: climatic niche models suggest that some rattlesnakes may have smaller ranges (11); while ratsnakes have increased activities due to warmer night temperatures (12).

Climate change concerns for turtles and crocodilians are three-fold. First, these mostly aquatic species may encounter altered habitats and increased habitat fragmentation with altered climate. In this regard they share many concerns with amphibians, such as sensitivity to changes in water availability and its' thermal properties. Second, turtles and alligators have temperature-sensitive sex determination: cooler temperatures may produce nests of only males; warmer temperatures may produce nests of only females. Temperature changes in a local area may have the effect of altering the sex ratios of populations - potentially affecting future reproduction and over time compromising their evolutionary fitness (13). Third, coastal species such as the American Alligator and Crocodile are susceptible to an increasing frequency or intensity of storms caused by increases in ocean temperatures. Storm surges can displace or drown animals, and dehydrate them by salt water intrusion into freshwater habitats (14). Because the United States is a biodiversity hotspot for turtles, and turtle conservation issues are multi-faceted, concern for climate change projections relative to rare turtle species is a specific concern (15).

Likely Changes

The highest biodiversity of reptiles in the United States is in the southern states, in desert and subtropical ecosystems. The northern distributions are constrained by latitude, with species richness dropping considerably as you go north. North boundaries of species ranges are often marginal habitats due to climate factors such as cool temperatures and weather variation. Altered thermal niches (4, 5) for reptiles in these zones due to climate change will be important to track. Briefly, to understand thermal niches, consider that there is a time-window during the day when there are suitable temperatures for reptile activities. It appears that this time-window is becoming smaller as climate changes are apparent in both tropical and temperate zone regions, reducing the activity times of reptiles, affecting their reproduction and survival. Although habitat may be marching northward or into mountains for some species, for other species, increased weather variation may alter the frequency or intensity of boom-bust reproductive cycles and cohort survival. Examples follow.

In Oregon, variable spring weather has been shown to narrow the time window of suitable breeding conditions for the Common Side-blotched Lizard, *Uta stansburiana*, with reproductive bust years being reported (6, 7). In Mexico, a study reported that 12% of local lizard populations have been lost since 1975, with evidence that these losses are associated with climate change altering thermal niches (4). In Alberta, Canada, the Greater Short-horned Lizard, *Phrynosoma hernandesi*, overwinter survival relies on persistent snow cover to retain animals in insulated hibernation: lizards become active during warm spells in winter, and then they can be 'caught out' and die when it snows again (8). In contrast, ratsnake thermal niches may be expanding with more warmer nights (12).

Vulnerability assessments and predictions of how habitat distributions will change abound for many taxa. Looming questions are where will suitable habitats occur in the future, and will organisms be able to get there? In our human-altered world, roads and urban-rural development are new hurdles to dispersing reptiles, added to a variety of natural geographic barriers. In Spain, the northward expansion of lizard ranges coincident with changing climate has been tracked over about a 50 year period, with geographic barriers including the Pyrenees Mountains now posing dispersal limitations (3).

Options for Management

For reptiles, management is of paramount concern to **maintain and restore existing habitats, augment acreages of intact habitat blocks,** and **adapt management actions to reduce environmental stressors** (see regional Habitat Management Guidelines at: www.parcplace.org [5]). Because microclimates can be readily manipulated with local land management activities, people can actively engineer a future for some of these organisms, especially when their environments are already highly altered due to human activities.

Invasive plant species and most human disturbances can alter local- to landscape-scale habitats and microclimates, which can have consequent effects on reptiles. Non-native vegetation may have different physical structure and cover, hindering reptile daily activities, and subsequently altering critical life history functions and reptile survival, and negatively influencing dynamics of interacting communities. Open habitat management may be needed to forestall encroaching vegetation, especially non-native plants, or to mitigate human disturbance (e.g., agricultural or energy development). Meadow shrub and tree control may be needed to retain sun-exposure. Riparian buffers may retain near-water refugia. For turtles or other water-dependent reptiles, manipulation of hydroperiod at sites by site excavation and riparian buffer management are considerations. Substrate management may be needed for several types of reptiles: rock outcrops and talus are complex refugia for lizards and snakes and may need protection or augmentation; rocky pond edges provide basking sites and antipredation refugia for turtles. Some species need specific substrate types, or rely on existing burrows created by other animals; these need consideration if climate change alters landscape-scale habitat distribution. Traditionally used snake hibernacula may need special protection. Management measures taken to maintain natural fire regimes and control invasive plants might also benefit reptiles. Altered fire regimes may change refugia, reduce cover and expose animals to heightened predation, and invasive plants may exacerbate climate-linked fire patterns.

Managers can facilitate the movement of reptiles by providing corridors between needed habitats that support complex reptile life histories: breeding, foraging, overwintering, anti-predation, and basking habitats can all differ. Corridors between overwintering hibernacula and foraging areas, or between upland nesting sites and aquatic breeding sites are a particular concern because these can be inadvertently affected by roads or development. Considerations include: 1) extension of riparian corridors along safe upland dispersal routes; 2) creating barriers to dispersal along unsafe routes, such as along roads or into disturbed areas; 3) road-crossing culverts that may require dry as well as wetted channel areas; 4) management of surface rock or burrow availability and connectivity.

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 reptiles (16), such as the captive propagation and reintroduction of Eastern Indigo Snakes (http://www.oriannesociety.org/ [6]). Broad-scale policies directed at vulnerable site protections warrant consideration.

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