Hope for salamanders? Study recalibrates climate change effects

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College of ACES researchers, including Sam Stickley (pictured), found plethodontid salamanders may not decline due to climate change as much as originally predicted, based on older species distribution models. Re-running those models using microclimate data more relevant to the salamanders' habitat, the researchers found less decline and even some areas where the amphibians may gain habitat by 2050. Credit: Sam Stickley, University of Illinois College of ACES.

For tiny salamanders squirming skin-to-soil, big-picture weather patterns

may seem as far away as outer space. But for decades, scientists have mostly relied on free-air temperature data at large spatial scales to predict future salamander distributions under climate change. The outlook was dire for the mini ecosystem engineers, suggesting near elimination of habitat in crucial areas.

Now, University of Illinois researchers are tuning into the microclimates that really matter to the imperiled amphibians and forecasting a somewhat more hopeful future.

"The older estimates were predicting almost 100% of the suitable habitat being wiped out for some of these species. But once we incorporated microclimate data at fine spatial scales for our study area in Great Smoky Mountains National Park (GSMNP), we found it might not be nearly that severe.

"It's still bad, though; our estimates showed 55-80% reduction in habitat for the three species we studied, but that's a big difference when we're talking about a large area," says study co-author Sam Stickley, assistant professor in the Department of Natural Resources and Environmental Sciences (NRES), part of the College of Agricultural, Consumer and Environmental Sciences at U of I. Jennifer Fraterrigo, also an NRES professor, co-authored the study.

Surprisingly, and for the first time, the team was also able to locate potential *gains* in highly suitable habitat area for three GSMNP plethodontid salamander species under future climate scenarios. Lacking lungs, plethodontids "breathe" entirely through their skin. They're currently quite abundant in GSMNP, Stickley says, but when their overall range begins to shrink in the future, the predicted areas of gain could be prioritized for conservation or park management.

But let's step back for a moment. Ecologists model species distribution

based on what they know about the critter's environmental requirements and where on the landscape those requirements may be met. The results are displayed like a heat map overlaid on real landscape features, with color gradients indicating low to high habitat suitability. It's usually an exercise done at large spatial scales: GIS maps showing soil and vegetation types on a kilometer scale or larger, along with climate models developed from regional weather stations.

But salamanders and other small animals don't operate on those scales. They're right up next to—or in—the soil, oftentimes carrying out their entire lives within a few square meters. At or near the forest floor, temperature and moisture are much more stable than in open areas, where weather stations tend to be located.

"Using free-air temperature data doesn't account for the buffering effect of forests," Stickley says. "The forest is pushing solar energy back out, absorbing it, altering wind patterns, and there are plant-water interactions; just all sorts of microclimate variables near the surface that aren't accounted for in typical climate layers."

With the advance of small digital environmental sensors, it's now easier to gather microclimate data at biologically relevant scales for ground-dwelling animals—for example, 3 square meters vs. multiple kilometers—but species distribution modeling using data at fine spatial scales is still relatively rare.

Stickley obtained a colleague's data from hundreds of mountaintop locations where the three salamander species, along with many others, make their homes (GSMNP isn't called the "Salamander Capital of the World" for nothing). He then ran distribution models for each species using standard data inputs (free-air temperatures) or microclimate data from the park, producing distribution maps for three time periods: 2006-2010, 2030, and 2050.

Again, the free-air models predicted much greater habitat loss by mid-century than the microclimate models for all three species. And they underestimated many areas the microclimate models predicted would become highly suitable habitat: a total of 3 square kilometers (km^2) for the Ocoee salamander, 9 km^2 for the pygmy salamander, and a whopping 39 km^2 for the red-cheeked salamander.

"The red-cheeked salamander is endemic to the Smoky Mountains, only found in a small range of high-elevation areas in Great Smoky Mountains National Park and a few little areas nearby," Stickley says. "To find a relatively large area of potential gain in highly suitable habitat could be important information for park managers and conservationists."

Stickley is optimistic that fine-resolution, microclimate-based species distribution models will become more common with increased data availability and better modeling techniques. In this case, they offer a glimmer of hope for the Salamander Capital of the World, but even microclimate-based models aren't perfect. They can't account for disease, predation, or other biotic interactions snipping the threads of the web of life. But, to Stickley, they're a worthy exercise if their outcome leads to conservation efforts to protect his favorite amphibians.

"Salamanders are a really integral part of the forest food web. They're eating all these insects and shredding and decomposing that stuff into the soil. They're also cycling nutrients across the forest, within the streams, and all the way up to the highest elevations," he says. "People don't realize how many salamanders are under their feet in a forest, performing all these key ecosystem functions. They collectively outweigh the biomass of every other vertebrate in the GSMNP, so the role they play in this ecosystem is extremely important to preserve."

The study, "Microclimate species distribution models estimate lower levels of climate-related habitat loss for salamanders," is published in the

Journal for Nature Conservation.

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