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# Science FINDINGS

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INSIDE



*"Science affects the way we think together."*

Lewis Thomas

## Working Together: How Science Partnerships Can Help Prioritize Rare Species for Conservation

USDI Bureau of Land Management

*The Great Basin collared lizard (*Crotaphytus bicinctores*), found in southeastern Oregon and other arid parts of the Western United States, ranked highest among Oregon reptiles evaluated by the newly developed Rarity and Climate Sensitivity index. The index provides a way to rapidly assess species that are rare and vulnerable to climate change.*

IN SUMMARY

*Resource managers are under increasing pressure to prioritize conservation efforts by assessing climate risk for numerous species. Amphibians, fish, and reptiles are particularly vulnerable to habitat alteration and climate change, yet many species fly under the conservation radar due to lack of basic information.*

*Dede Olson, a research ecologist with the Pacific Northwest Research Station, has forged science partnerships among researchers from diverse disciplines that are yielding rapid advances in species threat assessments.*

*Olson and three U.S. Geological Survey scientists developed an index to rapidly assess the vulnerability of freshwater fish, reptiles, and amphibians native to Oregon based on rarity and sensitivity to climate change. The index can be used to assess inherent climate sensitivity across entire taxonomic groups using existing data.*

*Olson also worked with geneticists from Washington State University and the University of Michigan to evaluate how landscape variables affect population connectivity for two salamanders found in Northwest forests. The partnership created a new avenue to address dispersal habitat associations for torrent salamanders, highlighting conservation needs that span the salamanders' life cycle.*

*Together, these studies illustrate how combining basic- and applied-science perspectives in partnered research is providing new insights for management of at-risk species.*

*"Two heads are better than one, not because either is infallible, but because they are unlikely to go wrong in the same direction."*

—C.S. Lewis

Amphibians, reptiles, and fish are especially sensitive to temperature changes in air and water. These ectothermic vertebrates, or ectotherms, which get their body heat externally from their environment––and ultimately the sun––often survive in a specific and sometimes narrow range of temperatures. Yet many ectotherms are rare and little is known about them.

"Amphibians are really at the top of the list of declining vertebrates around the world," says Dede Olson, a research ecologist with Pacific Northwest Research Station, "and they're of key concern in the Northwest."

Olson focuses on the ecology and conservation of amphibians and how to minimize the impact of human activities on them. She recently collaborated with scientists with differing expertise on two studies that yielded insights for conservation management of ectotherms. One study resulted in a new tool for assessing the combined rarity and climate sensitivity of ectotherms; the other shows how land uses are tied to the genetic connectivity of two species of torrent salamanders across a forested landscape.

## *Combining Rarity and Climate Sensitivity Information*

Climate change is affecting species faster than conservation science can keep up. That's how Meryl Mims, former U.S. Geological Survey (USGS) postdoctoral researcher and now assistant professor at Virginia Tech, explains the problem.

"What's more," she says, "we might not be aware of the effects on rare species. Our attention may be focused on certain flagship taxa like salmon, while others may be overlooked."

This observation catalyzed a Forest Service research partnership that joined Mims with Olson and USGS scientists Jason Dunham and David Pilliod. Each had been working separately on different aspects of species rarity and climate threats to ectotherms. Merging their research into a single study was a hallmark moment.

It's not practical to study every fish, amphibian, or reptile species in detail, but the scientists wanted to figure out how to determine among multiple species which face the greatest risk.

"We live in an increasingly data-rich world—including natural history data—so why not try starting there?" Mims says.

Among museum records, agency databases, and other sources, the researchers found enough existing data about where species occur in a landscape, the climate characteristics of those sites, and the species life history traits to assess both rarity and climate sensitivity. They envisioned a tool that could combine these factors so they could compare risk between species. The result was the Rarity and Climate Sensitivity (RCS) index, an approach capable of assessing not only multiple species, but multiple, higher level taxa across large regions.

The scientists analyzed 114 species native to Oregon. The list included 73 percent of all native freshwater fish species, all amphibians, and all but one reptile. Of the fish, 37 percent were flagged as having high RCS index values relative to other fish in the assessment—meaning these species occupy relatively small ranges and narrow climate niches. In comparison, 23 percent of the amphibians and 17 percent of the reptiles had high RCS index values.

Not surprisingly, fish species with high index values included those listed by the state as sensitive, threatened, or endangered as well as some other species thought to be at risk, including western chubs. Several amphibians also ranked high in the index, including two species proposed for listing under the Endangered Species Act (ESA): the Columbia torrent salamander (*Rhyacotriton kezeri*) and the Cascade torrent salamander (*R. cascadae*).

"Knowing that endemic species with rarity concerns like these two salamanders also have climate sensitivities will help inform both management and science priorities," Olson says.

The RCS index also flagged species not already on the conservation radar. Five nonlisted species of reptiles ranked higher than the western pond turtle *(Actinemys marmorata*), another species proposed for ESA listing. The Umpqua pikeminnow (*Ptychocheilus umpquae*), a species endemic to Oregon but about which little is known, turned up among the 10 fish species with the highest RCS index values.

"A high RCS value doesn't necessarily mean a species is in trouble," Mims says. "But this information gives managers some leverage to say, we really might want to take a closer look to see if this potentially vulnerable species is facing major environmental challenges."

### KEY FINDINGS

- Rarity and Climate Sensitivity (RCS) index values were higher for fish (37 percent) than amphibians (23 percent) and reptiles (17 percent). Concerns for several species were elevated, compared to rarity assessments alone.
- Five reptile species not currently listed as threatened or endangered had higher RCS index values than the western pond turtle (*Actinemys marmorata*), a state-listed species of concern.
- High RCS index values were found for torrent salamanders (*Rhyacotriton* species), including the Columbia torrent salamander (*R. kezeri*) and the Cascade torrent salamander (*R. cascadae*), which are proposed for listing under the Endangered Species Act.
- Genetic analysis shows that landscape connectivity among Columbia torrent salamander and southern torrent salamander (*R. variegatus*) populations was less in areas of forest fragmentation, specifically, areas with less forest cover and more roads.

Christopher Cousins

*The Columbia torrent salamander (*Rhyacotriton kezeri*) is found only in coastal forests of southwestern Washington and northwestern Oregon. It had the third highest ranking on the Rarity and Climate Sensitivity index.*


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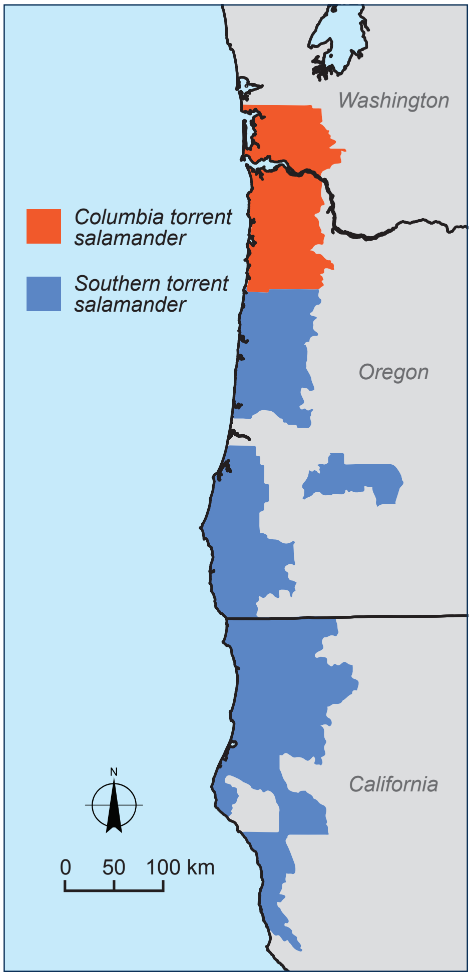



*Distribution map of the Columbia torrent salamander and southern torrent salamander. The Rarity and Climate Sensitivity index pulls from existing species locality datasets to assess risks to multiple species across large regions. This map was created with species distribution data from the International Union for Conservation of Nature.*

Kara Anlauf-Dunn, a research aquatic ecologist with the Oregon Department of Fish and Wildlife, agrees. To help resource managers make decisions about game fish, such as salmon and steelhead, she models how their distributions might be affected by changes in streamflow and temperature. But she says the agency lacks general information about many nongame fish species.

"Because so many of the species are considered nongame species, which we don't actively manage, data from the RCS index are the best that we have," she says.

She also says she appreciates that because the RCS index provides insights into the relative vulnerability of a large number of species, it can help the state agency make decisions about allocating resources.

The index is useful for identifying climate-sensitive species that would benefit from habitat management. The RCS is also useful for spotlighting species like the Siskiyou Mountains salamander (*Plethodon stormi*)––the highest ranking amphibian on the index––that may lack the resilience to keep pace with climate change and for which managing local habitat refugia is important. And, it can help identify species that may warrant other approaches because they can't successfully be protected in nature. For example, efforts to rescue the western pond turtle involve collecting eggs from the wild, hatching and "headstarting" them in captivity, and then releasing the young turtles back into nature.

Perhaps the greatest promise of RCS assessments is the potential to help forestall biodiversity losses at local, regional, and national scales––not only for ectotherms but for other taxa as well. At the same time, Mims recognizes the RCS has limitations. For example, she was surprised to discover that certain life history traits associated with a higher risk of extinction due to climate change—such as longer generation time, later maturation, fewer offspring, and high parental investment––did not line up with the RCS rankings as much as she expected.

"What that can indicate," she says, "is if we're trying to assess vulnerability using one tool alone, it's possible we still can be missing part of the picture."

Mims and Olson agree with Anlauf-Dunn that the RCS is a valuable tool for helping to decide where to allocate resources for conservation.

"Whether that's monitoring, thinking about efforts in the field, prioritizing data collection, or flagging species that could be at risk, it's perfect for those types of management questions," Mims says.

A more user-friendly version of the RCS is expected to be released as part of the USGS national biogeographic map in 2020. But because the RCS is based on the "intrinsic components of vulnerability"—whether a species is inherently vulnerable rather than due to external factors—Mims cautions that it shouldn't necessarily inform whether or not species should be listed.

"There's this huge piece that's missing, which is exposure to external factors, including climate or landscape changes," she says.

## *Salamander Conservation and Landscape Genetics*

Olson's research on the exposure of amphibians to landscape changes provides some of the missing pieces. Her research looks beyond ponds and streams where they breed to habitat where they're less easily encountered.

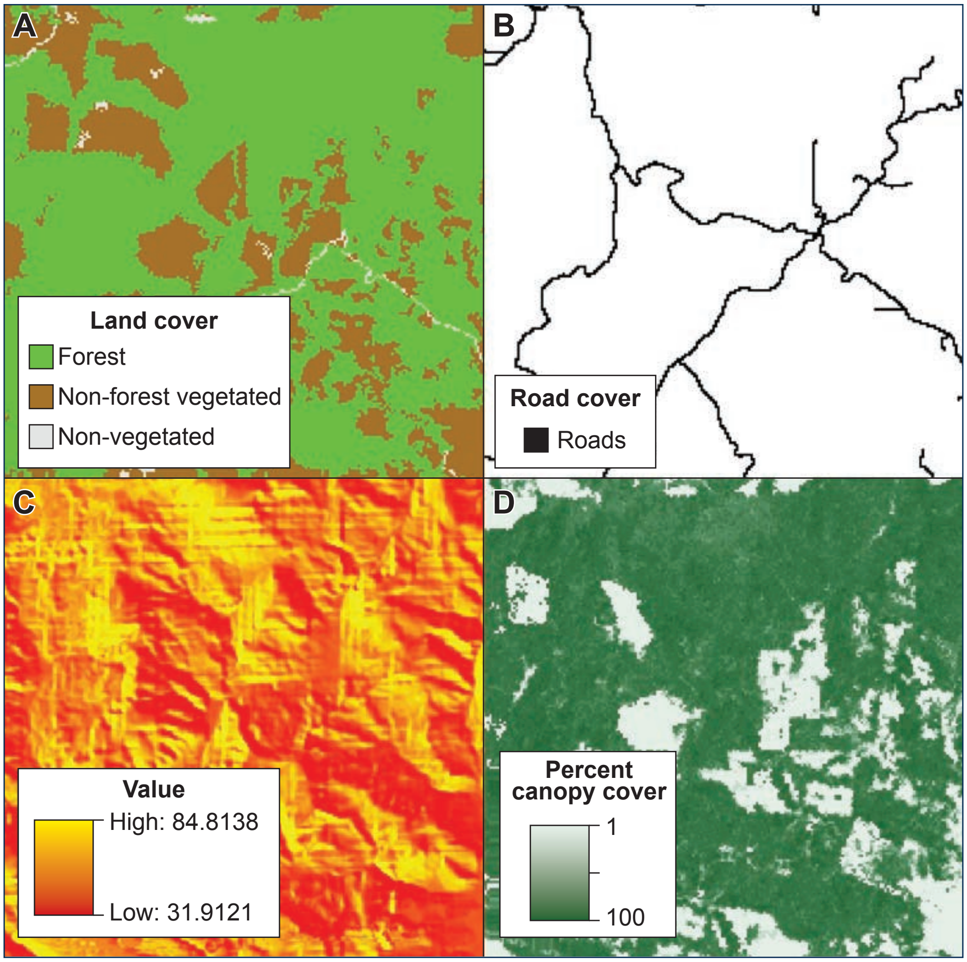
"Riparian and upland habitats used for foraging, refuge, overwintering, and dispersal to other breeding sites can be as important for their long-term survival," she says.

Her work on how stream-breeding salamanders move in a landscape, what landscape- and site-level factors are important for their persistence, and how human activities affect them informs forest management plans that optimize their survival.

Olson initially collaborated with geneticist Lacey Knowles and her students at the University of Michigan on a coastal giant salamander (*Dicamptodon tenebrosus*) study. While that work was in progress, a partnership with geneticists at Washington State University, doctoral student Sarah Emel and her advisor Andrew Storfer, evolved to understand how landscape factors are tied to the genetic structure of the Columbia (*R. kezeri*) and southern (*R. variegatus*) torrent salamander.

Sarah Emel

*Populations of southern torrent salamanders (*Rhyacotriton variegatus*) are at risk of becoming genetically isolated.*




*The landscape-scale genetic diversity among torrent salamander populations was best explained by (A) land cover, (B) roads, (C) heat load index (solar radiation), and (D) percentage of tree canopy cover.*

Torrent salamanders live in the cold, fast-moving streams (hence their name) that flow through forests of the coastal Pacific Northwest. They play a central role in the food web as predator of invertebrates and prey for larger animals. And because they are creatures of both land and water, they are an important engine of nutrient cycling between aquatic and terrestrial food webs.

These small amphibians are vulnerable to changes that affect their habitat in part because they occupy a narrow climate niche, a set of climate conditions to which they have adapted. They may also be at risk of becoming genetically isolated due to habitat fragmentation.

"If our actions as humans are creating barriers to movement," says Emel who is now an assistant professor at Indiana University of Pennsylvania, "individual populations can get isolated, and that can lead to decreases in genetic diversity and ultimately the potential for local extinction of populations."

Understanding how the two salamander species move in a landscape and mapping their gene flow, or genetic connectivity, would help the four scientists assess the risk of genetic isolation, and local extinction. But torrent salamanders are tricky to study in the field, and tracking individuals in uplands has been difficult.

These elusive amphibians are too tiny to track with a microchip, let alone a radio transmitter, and they spend most of their time in or near the water. Hatching from aquatic eggs, the larvae can take up to 5 years to metamorphose into an adult that can walk on land. Torrent salamanders are rarely observed in visual surveys or searches of natural or artificial cover, and marked animals are rarely recaptured in uplands.

"It's very challenging to measure movement without using genetics," says Emel, who has spent many field days lifting rocks hoping to catch a salamander in a net placed just downstream.

The scientists wanted to know which landscape habitat characteristics, including climate variables, could best predict genetic structure, and whether there was a relationship between genetic diversity and forest fragmentation in each species' range.

To get at these questions, they developed models based on a number of climate and landscape variables (annual frost-free period; temperature and precipitation; and land, road, stream, and percentage of canopy cover as well as topography) and genetic data obtained from 883 individuals collected across the species' ranges. Modeling the landscape as if it were a circuit—tracking gene flow instead of electricity—allowed them to account for *all* the potential paths of salamander movement between sites or between populations as well as the barriers that separate them.

Essentially, Emel says, "these species are not moving a ton."

There isn't much connectivity between populations, and a key reason is forest fragmentation. Among the 10 variables the scientists tested, land cover and roads were the biggest barriers.

Although genetic diversity was low within populations of both species, it was lower for the Columbia torrent salamander and corresponded to a higher degree of forest fragmentation in that species' range. The cumulative impacts of fragmentation, namely isolation and the potential for inbreeding, may be stronger for this species because it occupies a smaller range.

Nonetheless, both species depend on forest cover and cool headwater streams in a landscape where timber production is a dominant land use. The findings suggest that forest cover between the headwaters of small streams in adjacent drainages may be especially important for allowing salamanders to cross ridgelines and disperse their genes into neighboring watersheds. Maintaining forest cover may help prevent local extinction of torrent salamanders

Sarah Emel

*Stream habitat for southern torrent salamanders. They also use upland habitat for foraging, overwintering, and as dispersal corridors to other streams.*

due to genetic isolation—especially because their breeding habitat may differ from their dispersal habitat.

"Amphibians like torrent salamanders have a foot in the water and a foot on the land and need more than the water to persist over the long haul," Olson says. "Maintaining habitat and connectivity for breeding and dispersal is a much more effective pathway for species persistence and more economically sound than relying on rescue efforts of threatened and endangered species."

This is especially true if climate refugia, areas such as cold-water drainages or north-facing slopes that may be buffered from climate change over time, can be identified and protected.

The results of this study could help inform status reviews for the Columbia torrent salamander, which is proposed for ESA listing, and they may apply to the Cascade torrent salamander (*R. cascadae*), also proposed for ESA listing.

## LAND MANAGEMENT IMPLICATIONS

- The Rarity and Climate Sensitivity (RCS) index offers a way to rapidly assess species that are both rare and vulnerable to climate change, informing management priorities.
- RCS assessments of fish, amphibians, and reptiles in Oregon may be useful to fish and wildlife agencies in neighboring states and ecoregions.
- The RCS index is broadly applicable across regions, states, nations, and continents, allowing a common assessment of joint rarity and climate change sensitivity across taxa.
- Managing for dispersal habitat is an emerging conservation priority. Landscape genetics can inform management plans to protect overland forest-habitat corridors for torrent salamander dispersal among headwater drainages where they have breeding habitat.

## Insights and Hope for Conservation

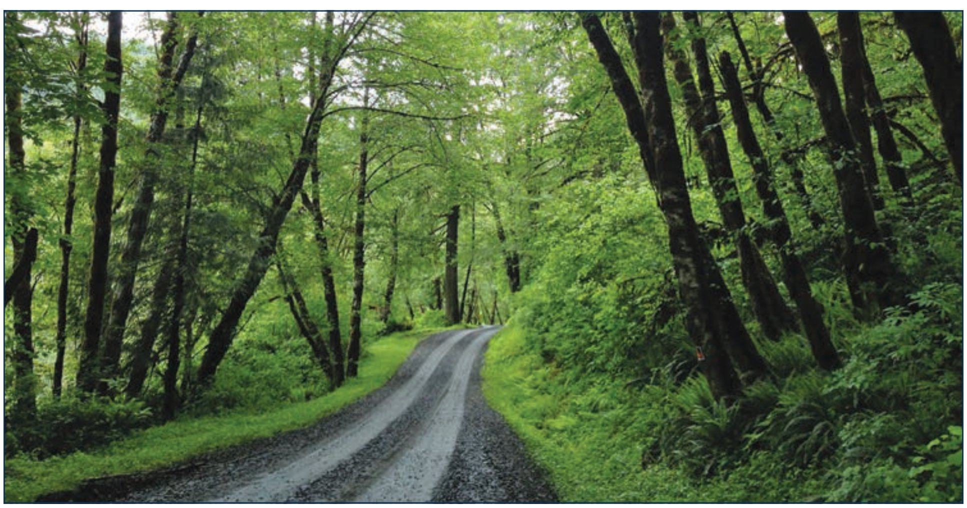
Insights from both the RCS index and landscape genetics studies can help managers and policymakers develop more effective conservation plans. Leveraging existing data with novel tools and predictive models to inform conservation actions may be the saving grace for a multitude of little-known species, Olson says. She hopes that with these new scientific insights, conservation efforts can better address previously overlooked species, and management decisions can take on multiple risk factors and broader landscape-scale considerations.

Olson also finds hope in her observation of a new level of rigor, vitality, and optimism for conservation efforts, which she attributes in part to greater collaboration among scientists and with managers.

"The tendency to keep science studies close to the vest until the revealing moment of publication can significantly stall the pace of developments," she says. "But strategic alignment of multiple studies among diverse collaborators is increasing our knowledge gain rapidly in the 21st century."

> *"Biological diversity is messy. It walks, it crawls, it swims, it swoops, it buzzes. But extinction is silent, and it has no voice other than our own."*
>
> —Paul Hawken

Sarah Emel



*Genetic patterns from the study support the hypothesis that roads and forest fragmentation are barriers that inhibit overland movement by torrent salamanders, corresponding to population isolation and reduced genetic diversity within populations.*

## Writer's Profile

*Sylvia Kantor is a science writer and editor based in Seattle, Washington.*

## Further Reading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Science FINDINGS

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## Scientist Profile

DEDE OLSON is a research ecologist with the U.S. Forest Service Pacific Northwest Research Station. She studies the conservation biology, behavioral ecology, and population and community ecology of amphibians and reptiles. Olson studies threats such as habitat loss and fragmentation, emerging infectious diseases, invasive species, and climate change, and development of alternative management approaches to maintain at-risk native species. In Northwest forests, she is examining stream-riparian management strategies and designs for habitat connectivity across landscapes that may benefit multiple taxa.

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