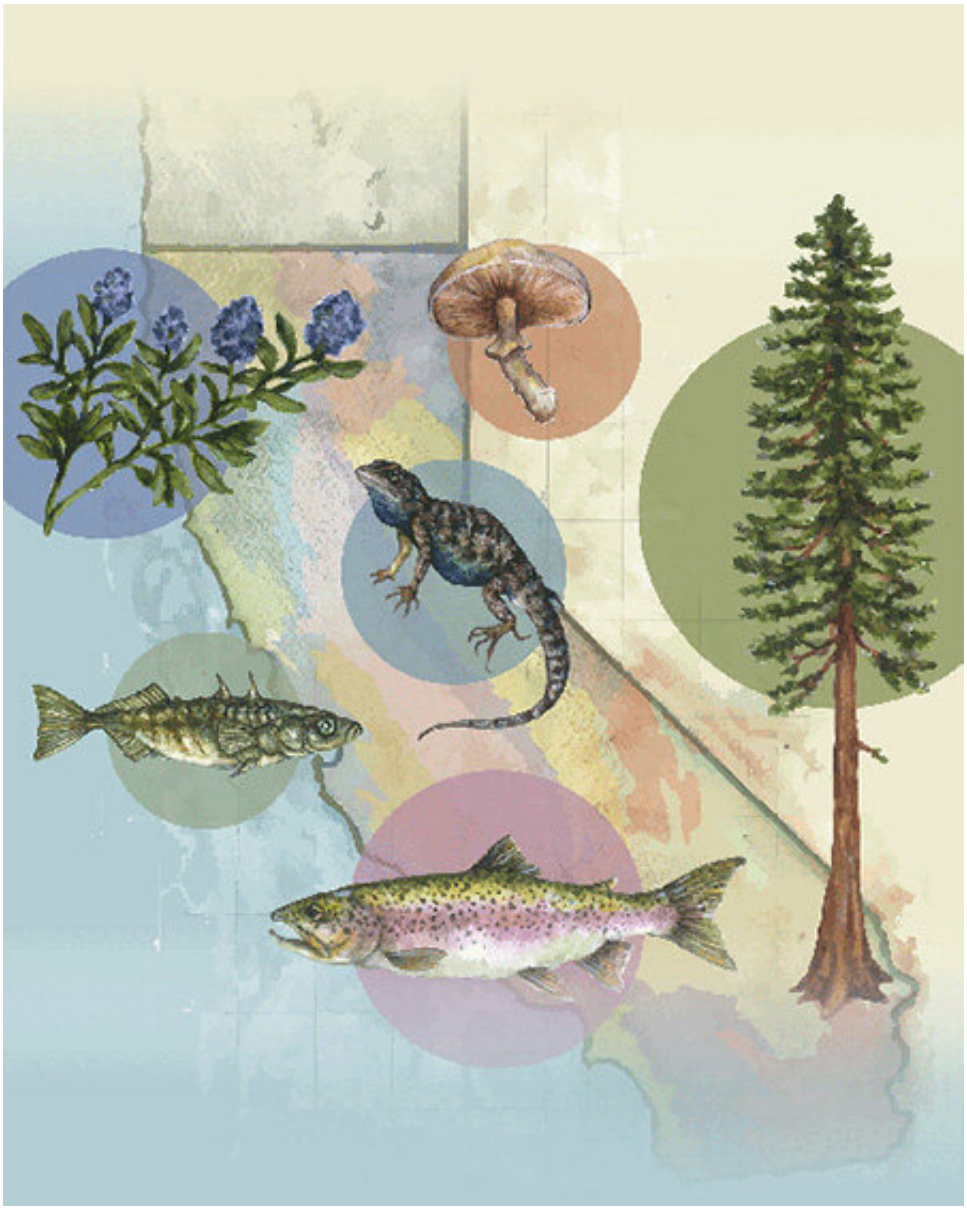
Missing the middle: The importance of regional-scale field research

May 20 2021, by Kathleen Wong



Regional-scale research networks such as the UC Natural Reserve System are

ideal for documenting the impact of climate change on plants and animals. Credit: Simone des Roches

Hundreds of biological field stations exist across the globe, supporting highly local, single-site projects as well as endeavors spanning continents. Yet few are networked on a regional scale. Likewise, current funding structures do not support regional science research over the long term. These omissions hamstring efforts to understand the climate crisis and its impacts plants and animals.

According to a new paper in the journal *BioScience*, regional field studies are the Goldilocks of climate change ecology: just right for examining the impacts of the climate crisis on plants and animals. "Many of these questions can only be answered at an intermediate, regional scale. That's the scale that is really important to organisms and their populations, because they involve dispersal and evolution," says coauthor Laurel Fox, a professor of ecology and evolutionary biology at UC Santa Cruz.

"We estimate where species will move in theory, but it's another thing to see them consolidate in slightly cooler microsites, demonstrating we have to protect spaces like this or else we're going to lose those organisms," says lead author Katie Stuble. Now a scientist with the Holden Arboretum in Ohio, Stuble was a UCSC postdoctoral fellow.

The foundational studies of ecology in the American West were all regional in scale, Fox points out. "Think about Joseph Grinnell's groundbreaking science surveying California vertebrates in the 1920s and 30s. He was able to look at hundreds of sites for many years." Scientists are now revisiting Grinnell's study sites to learn how animals have fared after a century of environmental change.

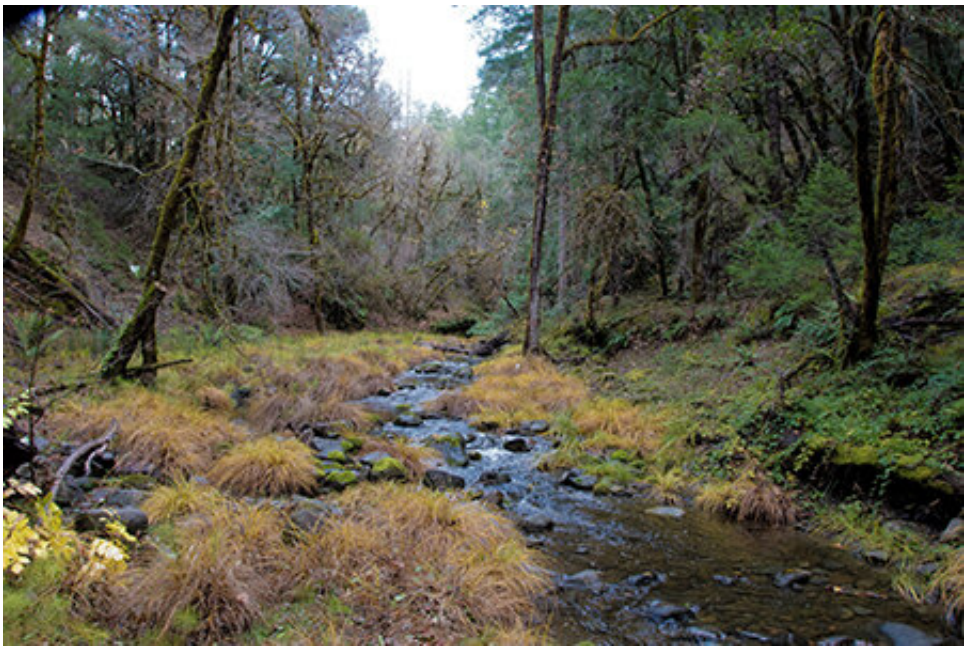
The authors cite the University of California's Natural Reserve System (UC NRS) as a premier example of a regional field station network. Located across California, the 41 reserves of the UC NRS feature examples of most major state ecosystems.

The regional scale of the UC NRS enables scientists to peer into the future with the help of geography. Southern California sites that are hot and dry today offer a glimpse of how climate change is expected to transform more northerly or high elevation locales. And because multiple UC NRS reserves have similar ecosystems, scientists can make "space for time" substitutions comparing, say, chaparral or oak savanna at different latitudes.

"The UC NRS provides a great backbone for thinking about global change research," Stuble says. "It's unprecedented to have replication of field sites at that fine resolution within a region like California."

A long record of research adds further value to studies of field stations like the NRS. "You can look at climate questions on spatial scales, and you can look at them on longer temporal scales. But when you have historic records, you can verify those trends, and that's the sweet spot," Stuble says.

Beyond the NRS, however, the authors were able to identify only a handful of other regional-scale networks. These include efforts to coordinate fire research and policy in the southeastern United States, marine productivity in the Caribbean, and freshwater lakes in Canada. Many of these networks have limped along with unstable funding that resulted in data gaps.



Angelo Coast Range Reserve in Mendocino County is one of 41 reserves in the UC Natural Reserve System. Habitats at the reserve include streams, mixed conifer and hardwood forests, and meadows. Credit: Lobsang Wangdu/UC NRS

The gaps in a global canvas

By contrast, networks pursuing work on continental or global scales are relatively plentiful. Many of these, such as the Long-Term Ecological Research Network and Critical Zone Collaborative Network in the United States, are funded by government agencies through targeted programs. These stable, long-term sources of support have enabled these programs to continue for decades.

Yet continental and global networks, the authors contend, lack the resolution to study processes occurring over finer gradients. For example, the National Ecological Observatory Network, which extends from Hawaii to Florida, relies on a single site to represent California's famously complex environment. The lack of funding for regional

research means concerns relevant to climate change and conservation are falling through the cracks.

"When you want to document global climate change dynamics, like where a specific lizard species is going to be in the future, you can't look at one site in the Sierra and one site in the Rockies; you would miss all the small shifts the species might make over the course of a century," Stuble says.

"It's not that research done at a local or continental scale isn't valuable. It's more that they address different questions," Fox says. "There's a lot of biology that's happening in the middle."

Strategic conservation

Regional research is of particular value for conservation. Where species are found now predicts the conditions they will require in the future. This type of data is already being used to model where species will move.

"Several hundred miles in California are variable in ways that are incredibly meaningful to organisms that might be dispersing just ten or a few tens of kilometers," Stuble says. For example, range shift information can identify areas to set aside for conservation. "If you understand that this microhabitat in this mountainous region will become key for conserving species in 20 years, then you would put your efforts into protecting those areas," she says.

Boyd Deep Canyon Desert Research Center offers access to high and low elevation Sonoran Desert habitats. Credit: Lobsang Wangdu/UC NRS

Shaping policy

Data from regional studies are well suited to guide environmental policies. For one thing, similar findings from multiple nearby sites add credence to findings. Governments "are not necessarily going to respond to one local entity crying out for a particular policy," Stuble says. But "if there are partners doing similar research throughout the state, we could say with high confidence that policy is critical."

Networks within a political jurisdiction can further amplify the influence of findings. "Policies are often enacted on the state level. States can enact financial or other incentives," Stuble says, effecting change on a broad scale.

For example, field research conducted within the UC NRS is poised to

help attain the environmental goals of its home state. Launched in 2018, the California Biodiversity Initiative seeks to safeguard California's natural heritage by restoring and protecting habitat.

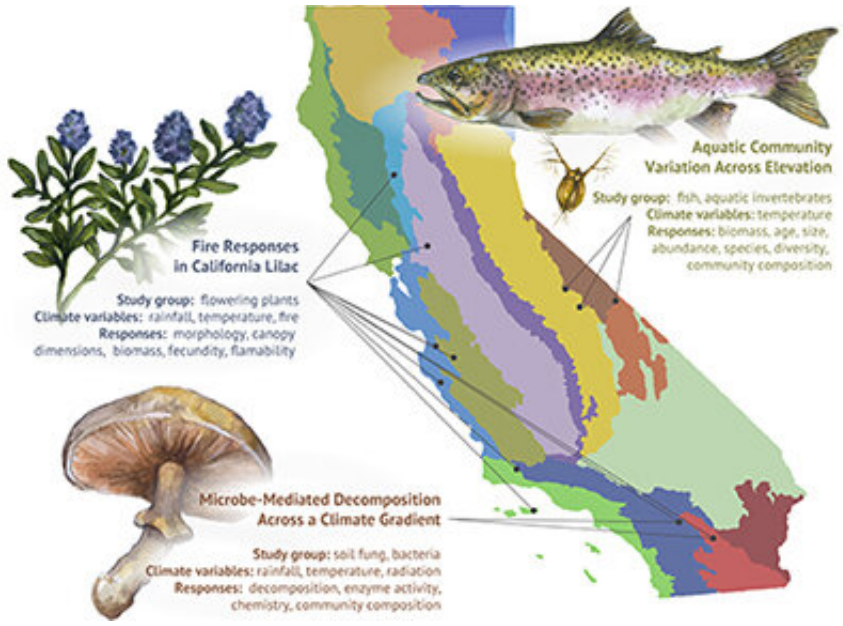
"Regional-scale research across the state would be ideal for implementing the California Biodiversity Initiative," Fox says.

"More regional work could help inform policies aimed at preserving California's biodiversity in the face of climate change and other threats," Stuble says.

A regional climate change institute

Fox and her late colleague, UC Santa Cruz Professor Barry Sinervo, were so taken with the potential to study climate change on a regional scale that they launched an institute to do just that. In 2015, they established the Institute for the Study of Ecological and Evolutionary Climate Impacts (ISEECI) with a five-year, $1.9 million grant from UC's Office of the President. The institute was specifically designed to leverage UC NRS reserves across California.

"We saw that this network of roughly 40 sites provides a wonderful backbone for research distributed across the region," Fox says. "We could go across a bigger array of sites than we'd normally be able to fund." The grant could defray the extra costs of doing research at several locations, such as travel among sites and the need to buy multiple sets of research equipment.



Three examples of ISEECI-sponsored graduate research synthesizing data from multiple UC NRS reserves plus neighboring other sites not mapped here. Projects examined the evolution of fire adaptation in California lilac, the effect of temperature on fish and aquatic invertebrates, and the impacts of radiation, rain, and temperature on microbial community function and composition. Credit: Simone des Roches

ISEECI funded postdoctoral fellows, including Stuble, and graduate students from across the University of California to examine how native species have responded to the climate crisis. Together, these findings document an astonishing array of ecological changes propelled by climate change.

For example, researchers from UC San Diego sampled Daphnia water fleas from Sierra Nevada lakes at several elevations, then grew them in warmer water at different altitudes. Temperature affected traits such as growth rates and body size in just a few generations, demonstrating the importance of genetic variation in adapting to climate change.

Another project sampled a lagoon-loving fish called the three-spined stickleback at 25 California estuaries, including two NRS reserves. Populations from drier southern California were known to have fewer bony plates in than those living further north, which needed armor against local predators. An ISEECI researcher from UC Santa Cruz found that over several decades, fish at northern location had lost plates, reflecting the influences of a drier climate.

Other ISEECI studies compared the impact of fog and drought on plant photosynthesis, local lizard population extinctions due to climate change, fire responses by California lilacs, and how environmental conditions across a climate gradient affect decomposition by fungi.

"It was both exciting and humbling to be able to provide a platform of protected areas for ISEECI research," says Peggy Fiedler, Executive Director of the UC Natural Reserve System. "The UC NRS facilitates exactly the kind of research needed to find both answers and solutions for climate resilience."

The funding conundrum

For Fox, the experience of running ISEECI underscored not just strengths but also pitfalls facing regional-scale field networks. "There's one-off funding for these kinds of regional studies, but not regular grants. It was so clear with ISEECI that you need institutional support, administrative support, for years to maintain this level of effort across multiple campuses and involving multiple faculty."

A prime example of what regional-scale field research can accomplish with steady support is Australia's Centre for Excellence in Coral Reef Studies. Incorporating multiple field stations operated by a variety of Australian universities and government agencies, the center has provided infrastructure and assistance to studies of the Great Barrier Reef since

2005.

Despite the barriers, informal regional networks of field stations continue to be formed to meet research needs. In time, strong demand may tip the scales to put regional-scale science—and the long-term funding it requires—on the map.

More information: Katharine L Stuble et al, Regional Networks of Biological Field Stations to Study Climate Change, *BioScience* (2021). DOI: 10.1093/biosci/biab048

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