Innovative model connects circuit theory to wildlife corridors

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Scientists at Northern Arizona University and the National Center for Ecological Analysis and Synthesis have developed a model that uses circuit theory to predict gene flow across landscapes. Their approach could give managers a better way to identify the best spots for wildlife corridors, which are crucial to protecting biodiversity.

"There are a lot of similarities between circuit theory and ecological connectivity," said Brad McRae, head of the project. "It's a powerful tool."

A 2005 doctoral graduate from the NAU School of Forestry, McRae, now a scientist at the National Center for Ecological Analysis and Synthesis in Santa Barbara, Calif., with his adviser Paul Beier of NAU School of Forestry, published this innovation in the Dec. 11 issue of *Proceedings of the National Academy of Sciences*.

McRae first hit on the idea while working with Beier on a study of genetic relationships of cougars across the southwest United States. "We had good maps of habitat and good maps of genetic data," he said, "and no way to see how one might affect the other." Using experience from his previous career as an electrical engineer, he reasoned that gene flow across a complex landscape should follow the same rules as electrical conductance in a complex circuit board.

The result was what McRae calls the Isolation by Resistance model. The model represents patches of habitat as nodes in an electrical circuit and the genes of animals and plants as the current that flows between the nodes. Flow occurs across multiple pathways, encountering more resistance in some areas—poor habitats or human-made barriers—and flowing preferentially through better habitats.

“I predict Brad’s model will become the standard way of modeling gene flow, and in a few years it will be seen as so intuitively appropriate that scientists will wonder why no one had seen the analogy before,” Beier said. “As a conservation biologist, I am most excited about the conservation implications of his model. It provides a meaningful way to evaluate how habitat fragmentation affects wildlife populations. More important, it can let us evaluate how restoring wildlife corridors can enhance gene flow and survival of wildlife.”

Corridors keep plants and animals from becoming trapped on small patches of land, where they would suffer from inbreeding and other problems that affect small populations.

Beier has been involved in designing corridors in Arizona and California since 2002 and recruited McRae to develop a more rigorous scientific basis for designing corridors.

“My worst nightmare is that scarce conservation dollars would be spent implementing my recommendations for a corridor, but then the corridor doesn’t work,” Beier said. “Brad’s model provides a realistic way to look at connectivity of the entire landscape rather than just a small part of the landscape.”

The resistance model incorporates multiple pathways, instead of just the most obvious one. It represents the landscape as a conductive surface, calculating all possible pathways connecting the patches. The *PNAS* article tested how well the new model explained genetic patterns across 12 wolverine populations across the United States and Canada, and eight big-leaf mahogany populations in Central America.

McRae and collaborators are now using the model to pinpoint critical linkages in landscapes and aid in conservation planning. “If you can imagine current flowing across a landscape, areas where it concentrates—bottlenecks or pinch points in the flow—typically correspond to important areas to maintain connectivity,” McRae said. “If you can distribute that current across multiple corridors, you’ll get greater connectivity, greater gene flow and greater robustness to climate change or catastrophes like wildfires.”

Source: Northern Arizona University

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