Optimization technique identifies cost-effective biodiversity corridors

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Wolverines (Gulo gulo), like this one photographed in Montana, are a rare member of the weasel family and are noted for their exceptionally large home ranges (roaming areas). Their primary habitat are areas with snowpack through May. Credit: U.S. Forest Service

A new optimization technique could help conservation biologists choose the most cost-effective ways of connecting isolated populations of rare, threatened and endangered species living in protected areas. As the human population grows and expands its footprint, maintaining the connectivity of animal habitats is a challenge. Habitat corridors are critical for keep wildlife species connected across the landscape.

The new computer-based method for corridor conservation accounts for the cost of land acquisition and other factors such as the ability of animals to move through certain types of terrain. The technique is believed to be the first to provide optimized corridor planning for more than one species at a time, using advanced computer technology to consider the costs and trade-offs for multiple options intended to enhance biodiversity.

The method has been used to identify cost-effective connections for both wolverines and grizzly bears simultaneously. Researchers say it could have broad applicability for providing connections between protected areas at multiple scales, from evaluating local easement options to developing national strategies.

The research was done by scientists from the Georgia Institute of Technology, the U.S. Forest Service Research and Development, Cornell University, Oregon State University and the U.S. Geological Survey. It was supported by the National Science Foundation and the U.S. Forest Service. Details of the work are scheduled to be published later this week in the journal *Conservation Biology*.

"This approach could revolutionize the process of corridor design," said lead author Bistra Dilkina, assistant professor in Georgia Tech's School of Computational Science and Engineering. "By incorporating economic costs and multiple species needs directly into the planning process, it allows for a systematic exploration of cost-effective conservation plans and informs policy-makers about trade-offs both between species as well as between costs and connectivity benefits."

Until recently, most efforts to ensure the survival of rare, threatened and endangered species involved creating protected areas for them. However, those areas don't provide a sustainable solution because populations become isolated and lose genetic diversity. So efforts were made to connect protected areas by purchasing and protecting natural corridors that the animals could use to move from one area to another. But until now, those corridors had been selected based on either on feasibility or the path most likely to be used by the species deemed most important.

"Many efforts have tried to prioritize which lands to swap or purchase for connecting rare species given biological and economic realities; this new research leads the way in optimizing the use of scarce resources to achieve essential connectivity," said Michael Schwartz, director of the U.S. Forest Service National Genomic Center for Wildlife and Fish Conservation and co-author of the study. "It provides a transparent solution for optimizing connectivity while taking into account economics."

To evaluate the new technique, the researchers used wolverines and grizzly bears in Montana as case study examples to demonstrate that finding optimal corridors for multiple species is possible, and now can be done with significant cost savings. The approach produced corridors that were within 14 percent and 11 percent of the best level of connectivity for grizzly bears and wolverines, respectively, while saving three-quarters of the cost. This type of multi-species optimization that includes real-world economic constraints is expected to become a game-changer in the world of conservation, Schwartz said.

The optimization program is based on mixed-integer programming, a technique that has been proven in many other applications. In this case, the program can consider large number of options, many more than humans could do alone. Dilkina said one of the surprises of the research was the highly nonlinear nature of the benefits. In one case, options for providing connectivity varied in cost from $3 million up to more than $30 million. The lowest-cost option provided pathways that the animals were unlikely to use, but by adding another $1.5 million to the low-cost option, the resulting corridor became nearly as good as the highest-priced option.

"There often is middle ground and that is what this tool helps find with a budget-constrained corridor design," Dilkina said. "There could be many corridors that are nearly optimal from an ecological standpoint, but there are different costs. Without these computer-based optimization tools, it would be difficult to find the most reasonable option."

The optimization program uses data on "resistance to movement" for each species, a measure determined by conservation biologists. Other data included the cost of acquiring tracts of land, and the location of protected areas. Claire Montgomery, a professor at Oregon State University, supported the economic aspects of the study.

In principle, the technique could be used to factor in the needs of more than the two species studied so far. But if ecologists carefully choose "umbrella" species that capture the needs of multiple species, solving the corridor problem for large numbers of species may not be necessary, Dilkina said.

With the recognition that many species of wildlife need more than one patch of land to persist, it is critically important to conserve tracks of land for wildlife migration corridors, Schwartz noted. This research will enable a clear path for cost-saving decisions, better targeting of investments and hopefully, more successful conservation of habitat for the long-term.

The work demonstrates how computer science and optimization programming can have applications to new areas such as sustainability, noted Carla Gomes, professor of computing and information science at Cornell University and another co-author. Cornell's Institute for Computational Sustainability received a $10 million NSF Expeditions in Computing Award that helped support the optimization research.

"This work opens up new directions in terms of understanding tradeoffs for different species," Gomes said. "If we can get synthesis rather than just optimize for one, it's more efficient."

Ultimately, the researchers hope to produce a computer-based tool that can be made available to conservation organizations and biologists to use.

More information: Bistra Dilkina, et al., "Tradeoffs and efficiencies in optimal budget-constrained multispecies corridor networks," *Conservation Biology*, 2016.

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