When animals share, conservation is affordable

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Grizzly bears in the Rocky Mountains are probably a bit lonely. They live mostly in two protected areas of federal, state and tribal lands: The Northern Continental Divide Ecosystem in northwestern Montana and the Greater Yellowstone Ecosystem in southwestern Montana and parts of Wyoming and Idaho.

The bear population of each area is too small to prevent inbreeding and loss of genetic diversity in this endangered species. Inbreeding can pass on too many deleterious recessive traits, and lack of genetic diversity makes a population vulnerable to catastrophic events such as the introduction of a disease.

Local land trusts have set out to help by acquiring land to create corridors through which animals might gradually migrate between the two preserves. At the same time, they have been designing corridors for also endangered wolverines and lynx.

Now, researchers at Cornell, Georgia Tech and the U.S. Forest Service have found that when a corridor includes areas that are hospitable to two species, the cost is far less than it would be to create separate corridors for each one. This also means more animals can be helped within the same limited budget.

"This work opens up new directions in terms of understanding tradeoffs for different species," said Carla Gomes, professor of computing and information science and director of the Cornell Institute for

Computational Sustainability. "The land trusts have very limited resources. Now that we can get synthesis rather than just optimize for one species, it's economically more efficient."

Gomes and colleagues began by creating optimization programs to design corridors just for grizzly bears, later applying the same techniques for other animals. Now they have updated their systems to work with multiple species, most recently trying it out with bears and wolverines.

Given the suitability of every available parcel of land, along with the purchase price, a computer can evaluate, in a "smart way," many possible combinations of connected parcels to find a route that best satisfies all the animals' needs at the lowest total cost.

Gomes is co-author of a paper, "Trade-offs and efficiencies in optimal budget-constrained multispecies corridor networks." published in the Sept. 27 online edition of the journal *Conservation Biology*. Cornell-related co-authors include Bistra Dilkina Ph.D. '12, now assistant professor at the School of Computational Science and Engineering at Georgia Tech, and Richard Bernstein, a staff programmer in the Institute for Computational Sustainability. Also participating are authors at the College of Forestry at Oregon State University.

"We were very fortunate to come across Carla and Bistra." said Michael Schwartz, director of the National Genomics center for Wildlife and Fish Conservation, an agency of the U.S. Forest Service, who is also a co-author of the paper. "I've talked to many land trusts and they are very enthusiastic to use this. This puts it in an economic framework that people can use in Western Montana or upstate New York."

Schwartz and colleagues in the Forest Service oversee 210 million acres of western land. They have collected genetic samples from more than 200 wolverines in the wild. "What got me interested is that I've seen our data being used to justify purchases," he said.

In the computer analysis, each parcel of land is assigned a "resistance score" that represents the difficulty a particular animal might have dwelling in that environment – and conversely, how much it might be attracted there. Bears, for example, like canopied forest. Wolverines prefer land that has snow on the ground into early spring. Both of them want to avoid predators, and none want to run into humans. The latter takes care of itself in the optimization process, Gomes notes, because land near towns is more expensive.

The computer's job is to evaluate many possible combinations until it finds a group of connected parcels that offer the lowest total of resistance scores and purchase prices. The computer scientist's job is to design an algorithm that will accomplish this in a reasonable amount of processing time – which gets harder as the number of species whose scores must be evaluated increases.

In tryouts, the researchers found there are many "tradeoffs," like accepting parcels that have higher resistance scores but are less expensive, or deciding to weight one species over another for ecological reasons or just to satisfy human preferences. (Bears seem to be more charismatic.)

The problem is common in computer science, Gomes said, using, for example, the same algorithms that might be used to route data packets around the Internet. The research paper describes new methods to deal with optimization problems that might otherwise require too much computer time to solve. One answer, Gomes explained, is for the computer to take a "reasoned approach," skipping combinations that start off looking worse than what was already available.

Sustainability work often pays back with new insights for common problems in computer science, Gomes pointed out.

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