Scientists hark back to Pleistocene to trace prioritary areas for conservation

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Identifying priority areas for action is a major challenge in biodiversity conservation projects. A group of researchers has chosen an approach based on past scenarios to try to understand the history of climate conditions in the regions analyzed.

"The regions that have suffered least from climate change in the last 21,000 years are those in which the fewest local extinctions have occurred. These regions stand out for their higher species richness ratios, genetic diversity among species and gene variability within the same population," said Thadeu Sobral-Souza, a biologist at the Rio Claro campus of São Paulo State University (UNESP) in Brazil.

The greater a population's genetic diversity, the higher its chances of surviving environmental change. Sobral-Souza is one of the authors of a paper that describes a methodology to identify climatically stable Amazon and Atlantic Rainforest areas that can be prioritized in conservation strategies. The study also determined which protected areas are already located in climatically stable areas.

Some of the group's findings have been published in the journal *Acta Oecologica* via a project led by Milton Cezar Ribeiro, a professor in the UNESP Ecology Department.

To determine which areas are climatically stable, the researchers first had to estimate the distributions of biomes in the past, especially before most of the Atlantic Rainforest was destroyed. They used ecological

niche modeling to simulate the distribution of these forests both now and in previous eras.

New technologies have facilitated the development of techniques to generate useful information from incomplete data. Species ecological niche modeling is one example. All species of animals and plants obey ecological rules that determine their geographical distribution. Even partial knowledge of the geographical distribution of a species in the present and the levels of environmental variation it tolerates (temperature highs and lows, rainfall, and so on) can be fed into computer algorithms and geoprocessing tools to obtain a quantitative representation of its ecological distribution.

Incomplete data for the geographical location of a species can be used to discover its current (or potential) distribution in the environment. Similarly, estimates of past climate conditions can be used to simulate the spatial distribution of species in previous periods.

"Although ecological niche modeling is normally used to infer species distribution, the technique is also deployed to predict biome delimitation by modeling the biome," Sobral-Souza said.

To predict variations in biome distribution over time, the researchers selected occurrence points using a geographical filter based on the current delimitations of the Amazon and Atlantic Rainforest biomes. Several atmosphere-ocean global circulation models that infer past global climate currently exist. "We used five of these models as data sources for simulations of the Amazon and Atlantic Rainforest climate in the past," Sobral-Souza said.

The researchers estimated the distributions of the two biomes using data such as annual mean temperature and annual precipitation as variables. The models were constructed on the basis of the current climate scenario

and simulated past scenarios for the peak of the last ice age in the Late Pleistocene, 21,000 years ago, and the middle of the Holocene, 6,000 years ago.

The simulations showed that the potential area of the Amazon biome 21,000 years ago was 3.28 million km^2, compared with a current potential area of 4.46M km^2, while the corresponding numbers for the Atlantic Rainforest were 3.85M km^2 and only 770,000 km^2, an 80 percent decrease.

To calculate climatically stable areas in the two biomes, the researchers superimposed the two paleomaps showing the biomes' distributions 21,000 and 6,000 years ago onto the map of their current distribution, thereby selecting the areas predicted to be suitable for biome occurrence in the three scenarios.

"Once we'd identified the overlaps showing climatically stable areas in all the scenarios, we analyzed the efficiency of currently protected areas," Ribeiro said.

They did this by mapping all protected areas and superimposing this map on the previous ones to show which protected areas were inside climatically stable areas and which were not.

To propose priority conservation areas, they mapped unprotected climatically stable areas and used the Intact Forest Landscapes database (http://www.intactforests.org) to infer which of these unprotected areas contain intact remnants of primary forest without anthropogenic modification, considering only large connected patches and excluding small or unconnected remnants.

Climate stability

Next, the researchers assigned each of these patches to one of three conservation priority categories. Very high priority areas were climatically stable, unprotected, and with large intact forest remnants.

High priority areas, the second category, were climatically stable, unprotected, and with fragmented forest remnants. The third category comprised medium priority areas, with more recent climate stability (in the last 6,000 years) and unprotected intact forest remnants.

"The results revealed three unconnected blocks of climatically stable areas in the Atlantic Rainforest biome, all near the coast," Ribeiro said. "The northernmost block comprises Paraíba and Pernambuco States all the way along the Zona da Mata region. The second coincides with the Serra do Mar and Serra da Mantiqueira ranges in São Paulo State, Serra dos Órgãos in Rio de Janeiro State, and Zona da Mata in Minas Gerais.

"In the Amazon, the climatically stable areas are broad and continuous, covering most of the currently existing biome. Most of them occur in eastern Amazonia, although smaller remnants were identified along the western and southern boundaries of the forest."

The researchers created an efficiency index, defined as the percentage of protected areas that encompass climatically stable areas. They inferred higher efficiency for protected areas in the Amazon than for those in the Atlantic Rainforest, finding that 40.1 percent of climatically stable areas in the Amazon are protected, compared with only 7.1 percent of climatically stable areas in the Atlantic Rainforest.

"The Amazon is more stable climatically than the Atlantic Rainforest, and protected areas in the latter are less efficient than protected areas in the former," Ribeiro said.

In the Amazon, the study identified climatically stable areas in all three

conservation priority categories—very high priority, high priority and medium priority. The areas of very high conservation priority in the Amazon biome are primary forest areas of western Amazonas State in the region bordering Peru, Colombia and Venezuela.

"Its geographical proximity to protected areas suggests that the creation of new protected areas or the enlargement of existing areas to include these high-priority areas could be an effective conservation strategy," Sobral-Souza said.

The high-priority areas in the Amazon are fragmented forests in climatically stable areas and are therefore in need of restoration. The high priority areas in western Amazonia are located near existing protected areas or intact fragments. In eastern Amazonia, they are forest patches surrounded by croplands and pasture, distant from intact forest areas.

"In these cases, reforestation is necessary to increase the efficiency of the protected areas in the region. The Amazon still has a major opportunity to expand conservation areas," Ribeiro said.

Sobral-Souza stressed that the situation is catastrophic in the Atlantic Rainforest biome. "No high-priority areas for conservation were identified because no more forest areas exist there. No intact forest or even fragments are left. Everything has been cleared in the last 500 years," he said.

The main climatically stable Atlantic Rainforest areas are small. They are relicts classified as high priority conservation areas. Only a few remnants exceed 10,000 hectares, and many occur in areas with low climate stability. The most important are in Pernambuco's Zona da Mata or the Serra do Mar State Park, "the largest Atlantic Rainforest remnant in Brazil," Sobral-Souza noted.

More information: Thadeu Sobral-Souza et al, Efficiency of protected areas in Amazon and Atlantic Forest conservation: A spatio-temporal view, *Acta Oecologica* (2018). DOI: 10.1016/j.actao.2018.01.001

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