Computer model shows how modern interventions affect tropical forests, indigenous peoples

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This agro-industrial field being prepared for soybean planting is in the midst of Brazil's Cerradao forest. A team of Stanford researchers has developed a computer model that can help understand the ways that activities such as clear-cutting might impact the future of the land and indigenous people who live in the Amazon rainforest. Credit: Jose Fragoso

People have thrived deep within the Amazon rainforest for hundreds of years without contact with the outside world. The constant encroachment of modern civilization, however, is putting the long-term sustainability

of these people, and the ecosystems they inhabit, at risk.

Now a team of Stanford researchers has developed a computer model that can help understand the ways that activities such as clear-cutting and welfare programs might impact the future of the land and the people who live inside protected areas of the rainforest. They hope the simulation serves as a useful tool for governments and other organizations that interact with the world's indigenous people.

Indigenous people control about half of the planet's undeveloped land. And in the tropics, hunting and habitat degradation are the major drivers in animal and plant population changes. Understanding how external factors influence the relationship between indigenous people and their land has significant policy implications.

The Makushi, Wapishana and Wai Wai are indigenous tribes that inhabit the Rupununi region of southern Guyana, where they survive as traditional forest-dwellers, growing cassava (tapioca plant) and hunting. The region has recently faced social and environmental changes caused in part by the government's attempts to integrate rural and urban areas.

For three years, Stanford biologist Jose Fragoso and his collaborators worked with these people to collect extensive information on local plant and animal species, as well as demographic information on the nearly 10,000 residents of the Rupununi region.

The scientists then used this data to develop a computer simulation model to gauge how future developments could impact the people, forest and wildlife in the region. They analyzed four of the most common drivers of social-ecological change in indigenous lands: introduction of advanced health care, abandonment of traditional religious and taboo beliefs, the conversion of land outside the indigenous area for large-scale agriculture, and the introduction of external food resources.

When the researchers evaluated changes in the intensity of the first three drivers via the simulation over a span of 250 years, agro-industrial land development outside lowered both biodiversity and the total number of animals and plants inside areas, as did loss of traditional taboos. Also, improved health care within areas had less of an impact on the environment. Eventually the ecosystem absorbed these impacts and leveled out to a new normal, even if those influences remained in place.

Clear-cutting the surrounding lands, for instance, lowered the amount of animals within the protected areas by a significant degree. But as the simulation played out, the system shifted to a new equilibrium with lower human population, animal abundance and forest cover.

The introduction of external food, however, may have lessened peoples' reliance on local resources and allowed the population to rapidly grow. This in turn placed higher pressures on both the animal populations and the forest, as people drew more heavily upon the natural resources of the region to sustain themselves. Eventually, the system collapsed in the simulation.

Population growth caused the disturbance, Fragoso said, but it was the introduction of food that triggered the population growth, highlighting the need for the careful introduction of essential resources from outside.

"It's important to bring food, but the way it is introduced makes a difference in whether the system stays stable or becomes unstable," Fragoso said. "The model behaves as if the food has been dropped in by a parachute, but in reality, local inhabitants and policymakers set policy for how the food arrives."

This is a modeling effort only, Fragoso said, but it provides a key for understanding the world and how society should proceed. Fragoso has been advising the Brazilian government on using the model to develop

and implement strategic and responsible subsidy programs. He suggests that supplying cash transfer programs in tandem with cultural support, education, fisheries and wildlife management will help people remain connected to their land and culture to preserve sustainability and maintain tropical forests.

"I believe this modeling tool has good potential to support participatory management and conservation of biodiversity in the Amazon region," said Carlos Durigan, the director of the Wildlife Conservation Society in Brazil. "But of course, we must combine it with a strategy of local involvement and good investments in technologies. The idea is to both monitor and develop a good basis for more responsible natural resources management and to construct an alternative way to ensure quality of life to indigenous populations facing a changing scenario both in terms of socioeconomics and environmental issues."

The paper was published in the journal *Frontiers in Ecology and the Environment*.

More information: Takuya Iwamura et al. Socio-environmental sustainability of indigenous lands: simulating coupled human-natural systems in the Amazon, *Frontiers in Ecology and the Environment* (2016). DOI: 10.1002/fee.1203

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