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Submitted by: Fundação Getulio Vargas (FGV)
Date: March 31, 2026

Contribution to the COP30 Presidency Roadmap on Halting and Reversing Deforestation and Forest Degradation by 2030

Artificial Intelligence and Forest Restoration

In recent years, the debate on climate change and deforestation has gained prominence in public and political discussions. Forest preservation has come to be recognized not only as an environmental issue, but also as an economic and social one, deeply connected to the urgency of climate change. In particular, the restoration of degraded areas has emerged as one of the most promising strategies to mitigate the effects of climate change, protect biodiversity, and recover essential ecosystem services such as carbon storage and sequestration and regulation of the water cycle.

Restoring forests on a large scale is a complex task. It's not just about planting trees: it's necessary to know which species to use, how to conduct the restoration process, where to prioritize interventions, assess the area's capacity to sustain tree growth, and understand how climate change can impact each of these decisions. Therefore, large-scale forest restoration requires continuous and comprehensive monitoring. This monitoring is only feasible with the use of images obtained by drones and satellites, as well as field sensors such as sound recorders and environmental DNA (eDNA) collection. This data is then processed and analyzed with the aid of artificial intelligence (AI) methods, capable of efficiently handling large volumes of information.

The challenge of data and the promise of AI.

As we have seen, restoring forests on a large scale requires well-informed decisions and continuous monitoring—tasks that only become feasible with large-scale data analysis, enhanced by the use of artificial intelligence (AI). This challenge is even greater when we consider that tropical forests and restoration projects often extend over thousands of hectares, frequently located in remote and difficult-to-access areas.

Monitoring these areas requires up-to-date, high-resolution data obtained from multiple sensors. Fortunately, recent advances in remote sensing have enabled the continuous collection of information on vegetation status, soil temperature, air humidity, and other essential environmental indicators to guide restoration efforts.

However, even with this abundance of data, one of the main challenges remains: the lack of field information that serves as a reliable reference for training and validating the models.In many cases, we know how forest cover has changed over time, but we lack precise data on which species are present, whether wildlife inhabits the area, or if natural regeneration is actually occurring.

To overcome this limitation, part of the research agenda developed at EMAp proposes the use of AI models capable of learning from a few reference examples—an approach known as self-supervised learning. In one of our papers, published at the AAAI conference, we developed a technique that allows the model to classify regions based only on aggregate proportion estimates provided by official censuses. This means that the model does not need to know exactly what is in each pixel of the image—it learns from aggregate data. This logic has also proven promising in the context of forest monitoring: it is possible, for example, to train models to estimate tree diversity from drone images and a few sampling points, as we demonstrated in a recent study on mapping tree species in the Atlantic Forest and the Cerrado.

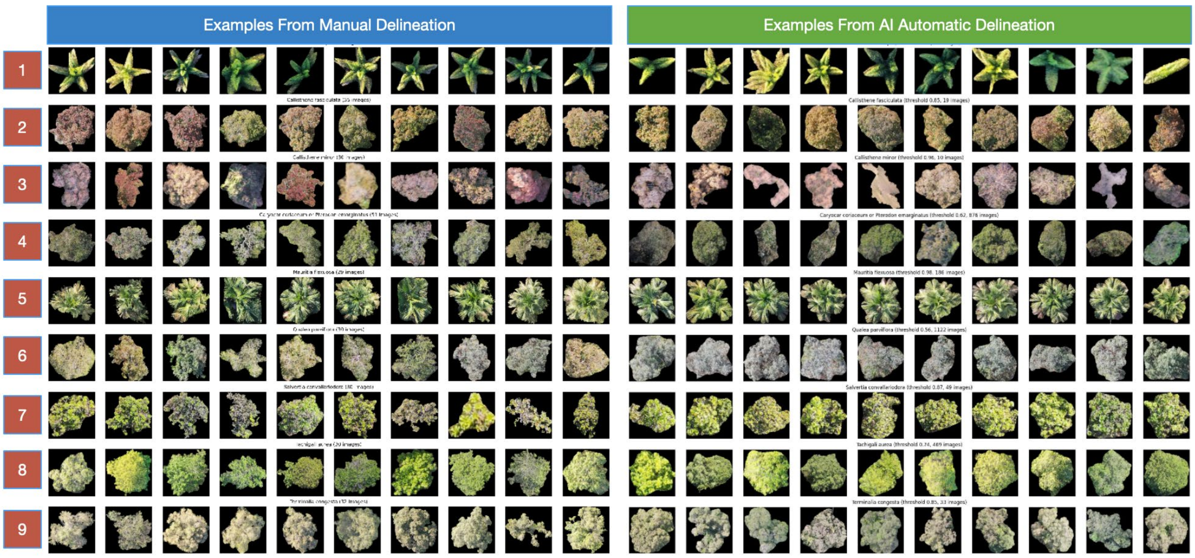

Figure 1: Classification of tree crowns based on deep clustering.

Automated landscape diagnostics

One research area that has been gaining prominence is the development of intelligent landscape diagnostic systems. These systems combine satellite imagery, drone data, field sensors, and climate information to generate automated maps that indicate, for example, where degradation is occurring, the regeneration potential of each area, and the most appropriate type of intervention.

Tasks of this complexity require models that work in a chain. Segmentation algorithms detect the contours of forest plots or fragments; classification models infer the successional stage of vegetation based on patterns of texture, color, and structure; and finally, historical and future climate information is integrated into this data, generating estimates of resilience to extreme events such as prolonged droughts and heat waves.

By adopting this approach, the models can estimate the ecological risk of an area and, with that, suggest more efficient restoration routes. This is an important step forward in moving away from visual or average-based diagnoses and towards an intelligent, evidence-driven understanding of the territory.

Connecting technology and conservation

The ultimate goal of these systems is to support public policy, environmental organizations, and local communities with reliable and accessible data. Tools like these have the potential to guide decisions about where to plant, which species to prioritize, and how to monitor the impacts of restoration over time.

At the Green AI Lab of FGV EMAp, efforts are focused on problems applied to biodiversity conservation, climate monitoring, and sustainable land use. Ongoing projects range from forest mapping with multisensory images to the development of AI-based systems for territorial analysis using real-world data on productivity, soil, and climate.

At this point, one of the great advantages of the widespread use of AI models is that it allows for highly granular diagnoses, as well as simulated responses considering different future climate scenarios, which ultimately can help foster more robust action strategies. For example, it is possible to predict whether a given area will have difficulty regenerating naturally due to changes in rainfall patterns and, therefore, prioritize active restoration techniques.

Restore intelligently — and urgently.

Forest restoration is a strategic pillar for tackling the climate emergency, but to be effective it needs science, data, and intelligence. In this sense, we see AI as an important tool that does not replace local knowledge or community involvement, but expands our capacity to see, understand, and act.

By teaching algorithms to understand forests, we are expanding our own understanding of them and building bridges between science, technology, and nature. With these bridges, we can make better, faster, and fairer decisions that can help us build a more resilient and sustainable future.