

## **Mapping Multifunctional Hotspots: A Spatial Approach to Prioritize Ecosystem Service Conservation in Brazil's Atlantic Forest**

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### **Abstract:**

Climate change and biodiversity loss threaten tropical forest ecosystems and the vital services they provide. This study addresses the challenge of optimizing ecosystem service (ES) provision in protected tropical forests by analyzing spatial synergies and trade-offs among carbon storage, water yield, and sediment retention in the Santa Virginia unit of Brazil's Atlantic Forest. Using the InVEST modeling toolkit alongside NASADEM elevation and MapBiomas land cover data, we identified that approximately 3% of the landscape accounts for nearly 60% of the potential ES benefits, revealing distinct multifunctional hotspots concentrated in high-elevation, low-disturbance forest areas. These findings highlight priority zones for cost-effective conservation and restoration under limited budget scenarios. Our results connect global-scale environmental concerns—such as breached planetary boundaries related to biodiversity and land use—with actionable local strategies. By demonstrating that targeted investments in a small fraction of the landscape can secure disproportionate ES gains, this work provides a science-based framework to guide policymakers in enhancing ecological resilience while supporting climate adaptation and water security. The Atlantic Forest's critical role in regulating downstream water supplies and maintaining carbon stocks is underscored. Key implications include the importance of spatially explicit ES mapping in restoration planning, the economic efficiency of hotspot-focused interventions, and the need to integrate ES synergies into protected area management. Future research should extend this approach to other tropical biomes and incorporate dynamic climate change feedbacks. This study advances nature-based solutions by showing that strategic, small-scale actions can yield outsized benefits for biodiversity conservation and human well-being in threatened ecosystems.

### **Keywords:**

Atlantic Forest conservation, ecosystem service hotspots, InVEST modeling, spatial prioritization.