

Forest Inventory & Trend Analysis

International Institute of Tropical Forestry

Reforestation efforts in Gurabo, Puerto Rico. USDA Forest Service photo by Preston Keres

A partnership for inventorying U.S. Caribbean forests

Understanding tropical forest dynamics requires the integration of plot-based and remotely sensed data across landscapes and through time. Since its establishment, the International Institute of Tropical Forestry (hereafter, "the Institute") has spearheaded efforts to characterize forest attributes, supporting science-driven forest management and advancing tropical forestry research in the U.S. Caribbean. A key initiative has been the Institute's long-standing collaboration with the Forest Inventory and Analysis (FIA) program of the Forest Service Southern Research Station. For decades, Institute scientists have collaborated with FIA specialists to conduct systematic forest inventories across mainland Puerto Rico and the U.S. Virgin Islands, evaluating, among other factors, the timber production potential of these island ecosystems.[1] The first such survey conducted in Puerto Rico revealed that the island had 130,000 hectares of potential commercial timberland.[2] The study also found that nearly half of the surveyed areas were adequately stocked with poletimber or saplings from several timber species.[3] Related efforts further identified 4,000 hectares of diverse plantations including mahogany (*Swietenia macrophylla*, *S. mahagoni*, and *S. macrophylla* × *mahagoni*), teak (*Tectona grandis*), eucalyptus (*Eucalyptus* spp.), Caribbean pine (*Pinus caribaea* var. *hondurensis*), maria (*Calophyllum brasiliense*), and mahoe (*Hibiscus elatus*).[4]

Later reports, including the 2007 FIA survey on Puerto Rico's forest resources[5] and subsequent Institute-sponsored studies,[6–8] have deepened tropical forestry knowledge through critical data on forest cover trends by forest type, carbon sequestration, important tree species, forest ownership, stand structure, and timber volume, growth, removals, and management activity. This information has been instrumental in guiding sustainable forest management and reforestation efforts at both local and regional scales.

Supporting species and landscape-scale research

Institute-led research has also enhanced the scope and applicability of forest inventory data. For instance, analysis of FIA plots in Puerto Rico showed that the biomass of the fast-growing non-native African tulip tree (*Spathodea campanulata*) declined between 2006 and 2016, while biomass of non-nitrogen-fixing native evergreen species increased. However, after hurricanes María and Irma in 2017, the African tulip tree's biomass rebounded due to increased light availability, whereas non-nitrogen-fixing evergreen species declined.[9]

Forest inventory data have been used in several Institute-led remote sensing studies in the Caribbean, including work that captured large-scale deforestation and subsequent forest regrowth in satellite-derived maps from Puerto Rico.[10] Institute scientists utilized advanced technologies for reconstructing a high-quality Landsat time series for detecting dry-season phenology in tropical forests in Puerto Rico, and evidenced the effectiveness of this approach for modeling aboveground biomass and leaf area index collected in field plots.[11]
Integrating forest inventory data with remote sensing and statistical methods has further helped understand the relationships between tree species composition, diversity, demography, and resilience to extreme events. This work has shown that indicators of stand-level drought resistance improve with stand-age, and that factors such as extreme weather intensity, stand-age, functional traits, and long-term climate influence storm-related tree mortality.[12]

Remote sensing elucidates how ecosystem properties affect forest carbon storage and responses to climate variability. Some of these efforts leverage the Global Ecosystem Dynamics Investigation (GEDI), a space-borne Light Detection and Ranging (LiDAR) instrument specifically designed to assess forest structure. A recent Institute-led investigation using GEDI-derived canopy height metrics found that elevation, dry season length, and solar radiation are the most important drivers in determining canopy height both locally and regionally.[13] These findings highlight the vulnerability of tropical forest structure to ongoing changes in the earth's climate and provide a valuable empirical baseline for management strategies. Additionally, by combining novel probabilistic classification algorithms with high resolution satellite data and machine learning classifications, GEDI has enabled the classification of logged and burned forests across the tropics.[14] These innovative approaches can also predict patterns in ecosystemic parameters like forest biomass, offering new tools for gathering detailed scientific data to inform forest management, conservation policies, and restoration programs.

Forest inventories: the path forward

At the Institute, we are using forest inventory data to understand how urban trees influence ecosystemic processes in disturbed environments. Accordingly, we plan to utilize FIA plots established in the San Juan Metro region to better understand drivers of spatial and temporal dynamics in carbon storage in urban trees and soils, as well as changes in species composition, cover, structure, and ecosystemic services. Following a community-level urban forest planning approach, we plan to conduct tree inventories at the neighborhood scale complemented with basic tree management training for residents of two target communities in the Río Piedras watershed. These efforts complement the Institute's long-term biophysical research on the region's forests and working lands, providing valuable insights for policymakers, scientists, and students engaged in forest conservation and sustainable management.

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