USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

International Institute of Tropical Forestry | July 2025



Science Supporting Fire Management

International Institute of Tropical Forestry

Wildfire in Maricao, Puerto Rico, 2023

Fire Science on Tropical Forests

Wildfires endanger life and property, but also trigger cascading environmental impacts. In Puerto Rico and the U.S. Virgin Islands, addressing wildfires is further complicated by the fact that tropical ecosystems developed without a natural fire regime. Delineating adequate preventive measures and management strategies in this region has been further hindered by the lack of comprehensive forest fire data[1].

The International Institute of Tropical Forestry (IITF) delivers research, capacity-building resources, and policy-relevant knowledge to enhance ecosystem resilience and mitigate fire-related risks in tropical regions. Global estimates of fire frequency indicate that over 70% of active fires occur in the tropics, and the size and frequency of fires are increasing every year[2]. Fire-centered efforts from the Institute range from developing conceptual models to guide fire-associated ecosystem management[3] to utilizing soil charcoal decay rates for reconstructing paleofire disturbances and their lasting impact on modern forests[4].

Forest Monitoring

Forest monitoring and wildfire prevention work comprise a wide array of cross-unit efforts aimed at improving the understanding of fire-prone forest conditions and building capacities among communities in high-risk areas to prevent and mitigate the social and ecological impacts of wildfires. For instance, strong collaboration among Institute scientists and Forest Inventory Analysis Program counterparts have resulted in detailed quantification of forest fuels in Puerto Rico and the U.S. Virgin Islands. An evaluation of 121 forest inventory plots validated

the increased importance of smaller-sized fine woody debris in shaping U.S. Caribbean forest fuel composition[5]. Continued surveying efforts evidenced satisfactory growth rates of native tree plantings in dry forests. These reduce the threat of grass fires and restore wildlife habitats[6]. Additionally, the Institute's State, Tribal and Private Forestry (SP & TF) Cooperative Fire Program has set up eight weather stations across the island to monitor conditions that can lead to fires in forests.

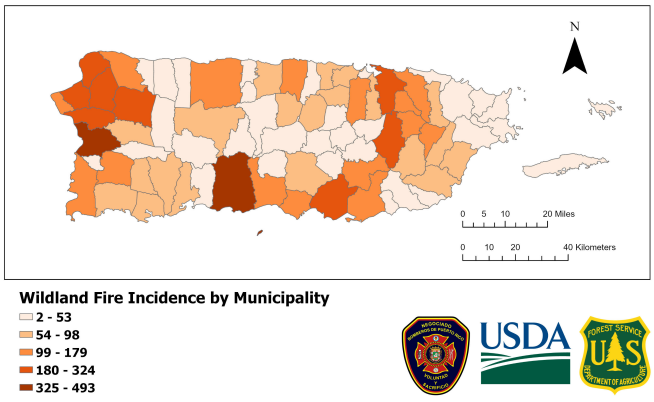
Understanding Wildfire Dynamics

Wildfire dynamics research examines how abiotic and ecological factors shape wildfire frequency and magnitude across spatial and temporal scales. Analyzing fire occurrence records for Puerto Rico has shown how the time of the day, mean minimum temperatures, and percent forest cover influences fire occurrence in the island[2]. The use of Machine Learning techniques to analyze data on climate, socio-economic factors, and fire history shows that the climate alone can define a fire season in a location[7]. IITF scientists assessed forest fragmentation along climatic gradients to help manage forest fuels and predict fire behavior[8]. Other ecological studies show how nurse trees may limit fire damage by reducing the amount of forest fuels[9]. Detailed analysis of fuel loads reveal that fire frequency may vary among native and exotic grass patches[10]. Similarly, research showed that tree bark thickness influences the vulnerability of Caribbean dry forests to fires. This is because trees in areas where disturbances, such as hurricanes, suppress stem diameter rarely reach large enough diameters to be fire resistant[11]. In two complementary long-term studies, Institute scientists observed how prescribed fire affects pasturelands of Puerto Rico through changes in soil arthropods, UV radiation and litter chemistry. The studies suggests that tropical grassland ecosystems can be highly resilient to fire disturbances, and that prescribed burns can be a good maintenance practice to support the health and productivity of soil[12,13]. Insights gained from these studies help develop predictive models of fire occurrence and projecting future fire risk scenarios.

Fire Incidence Analyses

Fire incidence analyses and impact assessments characterize the ecological impacts and social consequences of fires, and help us understand post-fire environments. IITF scientists analyzed land management reports and MODIS fire detections, revealing discrepancies between reported and observed fire activity in the insular Caribbean. They found that fires primarily occur in dry forests near human settlements, which are highly fire-sensitive and prone to degradation from invasive species[1]. Conversely, research on post-fire conditions led to the development of an integrated soil burn severity index, which characterizes the diverse impacts of wildfires[14]. As wildfires grow more frequent and human demands on forest resources intensify, these tools will be instrumental in shaping adaptive fire management strategies, not only in Puerto Rico and the U.S. Virgin Islands, but also in tropical regions with similar socio-ecological and environmental challenges.

Wildland Fire Incidence in Puerto Rico From 2019 to 2024



USDA is an equal opportunity provider, employer, and lender.

Literature cited

1. Robbins, A. M. J., Eckelmann, C.-M. & Quiñones, M. Forest Fires in the Insular Caribbean. *AMBIO: A Journal of the Human Environment* 37, 528–534 (2008).

2. Monmany, A., Gould, W., Andrade-Nunez, M., González, G. & Quiñones, M. Characterizing Predictability of Fire Occurrence in Tropical Forests and Grasslands: The Case of Puerto. in *Forest Ecology and Conservation* vol. 77, (2017).

3. Lugo, A. Fire and wetland management. in *Fire in wetlands: a management perspective* (eds. Cerulean, S. & Engstrom, R.) vol. 19, (Tallahassee, 1995).

4. Huang, W., Liu, X., González, G. & Zou, X. Late Holocene fire history and charcoal decay in subtropical dry forests of Puerto Rico. *Fire Ecology* 15, 1–14 (2019).

5. Brandeis, T. J. & Woodall, C. W. Assessment of Forest Fuel Loadings in Puerto Rico and the US Virgin Islands. *AMBIO: A Journal of the Human Environment* 37, 557–562 (2008).

6. Weaver, P. L. & Schwagerl, J. J. Secondary Forest Succession and Tree Planting at the Laguna Cartagena and Cabo Rojo Wildlife Refuges in Southwestern Puerto Rico. *AMBIO: A Journal of the Human Environment* 37, 598–603 (2008).

7. Van Beusekom, A., Gould, W.A., Monmany, A.C. *et al*. Fire weather and likelihood: characterizing climate space for fire occurrence and extent in Puerto Rico. *Climatic Change* 146, 117–131 (2018).

8. Gould, W., González, G., Hudak, A. & Hollingsworth, T. Forest structure and downed woody debris in boreal, temperate, and tropical forest fragments. *AMBIO: A Journal of the Human Environment* 37, (2008).

9. Santiago-García, R. J., Colón, S. M., Sollins, P. & Van Bloem, S. J. The Role of Nurse Trees in Mitigating Fire Effects on Tropical Dry Forest Restoration: A Case Study. *AMBIO: A Journal of the Human Environment* 37, 604–608 (2008).

10. Thaxton, J. M., Van Bloem, S. J. & Whitmire, S. Fuel conditions associated with native and exotic grasses in a subtropical dry forest in Puerto Rico. *Fire Ecology* 8, 9–17 (2012).

11. Wolfe, B. T., Saldaña Diaz, G. E. & Van Bloem, S. J. Fire resistance in a Caribbean dry forest: inferences from the allometry of bark thickness. *Journal of Tropical Ecology* 30, 133–142 (2014).

12. Huang, W., González, G., Barberena-Arias, M. F., Liu, W. & Zou, X. Changes in soil arthropods and litter nutrients after prescribed burn in a subtropical moist pastureland. *Pedobiologia - Journal of Soil Ecology* 106, (2024).

13. Huang, W., González, G., Barberena-Arias, M.F. et al. Litter decomposition and arthropod composition under different ultraviolet levels following prescribed burn in a subtropical pastureland. *Biology and Fertility of Soils* 57, 153–161 (2021).

14. Jain TB, Gould WA, Graham RT, Pilliod DS, Lentile LB, González G. A soil burn severity index for understanding soil-fire relations in tropical forests. *AMBIO: A Journal of the Human Environment* 37, 563-568 (2008).