AIRTREE 2.0: predicting ecosystem services provided by Italian urban parks under climate change scenarios

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In an era of climate change and increasing air pollution, accurately quantifying forest ecosystem services—particularly in urban environments—is essential. Species selection for urban and peri-urban green spaces requires identifying trees that are both climate-resilient and effective at carbon sequestration and pollutant removal.

We present an upgraded version of the AIRTREE multi-layer canopy model to assess ecosystem services provided by Italian urban parks established under a national reforestation program. Simulations were performed under two climate scenarios (RCP4.5 and RCP8.5) projected for 2054. The analysis focused on NPP (Net Primary Productivity), O_3, NO_2, CO, SO_2, $PM_{2.5}$ and PM_{10}, as well as BVOCs, including isoprene and monoterpenes. Model reliability was tested against Italian ICOS sites with measured carbon fluxes.

Model calibration showed rapid convergence and robust performance, with high accuracy for GPP (Kling–Gupta Efficiency, KGE, up to 0.90) Sensitivity analysis highlighted photosynthetic capacity (Vcmax) as the dominant control in Alpine and Continental sites, whereas stomatal regulation and water stress parameters were more influential in Mediterranean ecosystems. Across both climate scenarios, southern Mediterranean sites consistently showed the highest NPP. Under RCP8.5, NPP significantly increased (+9%), along with evapotranspiration (+8%) and BVOC emissions, while O_3 and NO_2 decreased and PM_{10} slightly increased. Species-specific responses confirmed strong functional heterogeneity, with *Sorbus torminalis* maximizing O_3 uptake, *Pinus halepensis* excelling in PM removal and *Quercus pubescens* showing high carbon sequestration.

As an open-access tool, AIRTREE provides robust support for evaluating ecosystem services under current and future climate scenarios.