Bird taxonomic and functional diversity across Mediterranean urban forests: a multi-scale assessment

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Abstract
Urban forests are increasingly important components of urban green infrastructure, yet the relative roles of local habitat structure and surrounding landscape context in shaping urban bird diversity remain insufficiently integrated. We assessed taxonomic and functional diversity of bird assemblages across 12 urban and peri-urban forests in Florence, Rome and Campobasso (Italy). Birds were surveyed in 111 hexagonal plots during the 2023–2024 breeding seasons, and local forest structure, tree-related microhabitats, deadwood and landscape metrics were linked to species richness, abundance and functional dispersion (FDis) using Random Forest models interpreted with SHAP. Across all sites, 2,035 individuals belonging to 52 species were recorded. The three biodiversity dimensions showed contrasting responses across scales. Species richness and FDis were primarily associated with local predictors, especially forest structure, indicating that crown development, stem density and vertical heterogeneity enhance habitat complexity and niche opportunities. By contrast, abundance was more strongly explained by landscape-scale variables, particularly forest aggregation and land-cover heterogeneity, highlighting the importance of the broader urban matrix for movement and resource access. SHAP responses further suggested non-linear relationships, with diversity generally peaking at intermediate levels of landscape heterogeneity and forest aggregation. City identity played only a minor role, with a modest residual effect detected mainly for FDis. These results show that Mediterranean urban bird communities are shaped by complementary drivers operating at different spatial scales. Biodiversity-friendly planning should therefore combine stand-level management aimed at retaining structurally diverse forest patches with landscape-scale strategies that enhance heterogeneity and connectivity within urban green infrastructure.

Keywords: *urban forests; bird diversity; functional diversity; habitat structure; landscape heterogeneity*