Publication status: This preprint has been published elsewhere.
DOI of the published preprint: https://doi.org/10.1590/1677-941X-ABB-2026-0034

Dynamics of palm tree invasion control in an urban remnant of the Atlantic Forest

Maurício Lamano Ferreira, Raffaele Lafortezza

https://doi.org/10.1590/SciELOPreprints.17240

Submitted on: 2026-07-31
Posted on: 2026-08-03 (version 1)
(YYYY-MM-DD)

ACTA BOTANICA BRASILICA

Sociedade Botânica do Brasil
ISSN: 1677-941X
acta.botanica.org.br

Dynamics of palm tree invasion control in an urban remnant of the Atlantic Forest

Maurício Lamano Ferreira

Universidade de São Paulo, Departamento de Ciências Básicas e Ambientais, Lorena, SP, Brazil. ORCID: http://orcid.org/0000-0002-7647-3635

Raffaele Lafortezza

University of Bari Aldo Moro, Department of Soil, Plant and Food Sciences, Bari, Italy. ORCID: http://orcid.org/0000-0003-4642-8435

Abstract

Biological invasions are a major driver of biodiversity change, particularly in disturbed urban forests where propagule pressure favors opportunistic species. Here, we document the demographic expansion and biomass contribution of the invasive Australian palm Archontophoenix cunninghamiana H.Wendl. & Drude in an urban Atlantic Forest remnant in São Paulo, a subtropical megacity in southeastern Brazil. Using one hectare of permanent plots monitored between 2017 and 2022, we quantified palm density and assessed changes following management actions implemented by municipal authorities. We also compiled official data on removed individuals in 2021 and estimated aboveground biomass using the allometric model of Hughes et al., (1999). Prior to management, density reached 391 individuals ha^{-1}, decreasing to 138 individuals ha^{-1} after removal. Official records indicated the removal of 738 individuals, storing 3.3 tons of aboveground biomass, with medium-to-large individuals contributing most to biomass stock. Despite its carbon storage, the high density and regenerative success of A. cunninghamiana relative to native palms may intensify biotic homogenization and threaten recruitment dynamics in urban forest remnants and adjacent Atlantic Forest landscapes. Our findings highlight the need for coordinated prevention and management to reduce propagule pressure from ornamental plantings and limit invasion spread across metropolitan forest fragments.

Keywords: Atlantic Forest; biological invasion; biomass; demography; invasive palm; urban forest.

Anthropogenic disturbance and climate change have accelerated biological invasions, increasing risks to native biodiversity worldwide (Cowie et al., 2022; Trisos et al., 2020). Climate change is among the major drivers of shifts in biogeographic patterns and biodiversity loss at a planetary scale (Boisvert-Marsh & Blois, 2021), and it can facilitate the establishment and spread of alien species (Solarz et al., 2023). The invasion of alien species has therefore been widely debated due to its potential to alter community composition and ecosystem functioning, often displacing less competitive taxa. Invasion processes can severely alter environments and community structure (Gentili et al., 2021), and land-use change (e.g., deforestation and urbanization) can facilitate the proliferation of non-native species and ecologically unsuitable plantings (Ferreira et al., 2021). Among biological invasions across major life forms, alien plant species deserve particular attention because plant structure habitats, regulate resources, and support trophic interactions. Many invasive plant species exhibit high propagule production and rapid biomass accumulation, which can increase water demand and alter disturbance regimes, including fire (Te Beest et al., 2012; Pepe et al., 2022; Shiba et al., 2024).
Urban areas play an important role in the dissemination of invasive species through deliberate introduction and through niche opportunities created by disturbance and habitat fragmentation (Sołtysiak, 2020), even when cities within the same country differ markedly (Ferreira et al., 2025). Urban expansion has been associated with biodiversity loss and biotic homogenization (Lowry et al., 2020; Lokatis & Jeschke, 2022), which may increase invasion opportunities. In parallel, the economic costs of biological invasions can be substantial, with multi-decadal expenditures reported for national control programs, including estimated losses and management costs exceeding US$ 298 billion in Australia since the 1960s and US$ 9.8 billion in Germany between 1960 and 2020 (Haubrock et al., 2021; Bradshaw et al., 2021).
In the megacity of São Paulo (southeastern Brazil), the Australian palm Archontophoenix cunninghamiana H.Wendl. & Drude was originally introduced as an

ornamental species and has progressively expanded into urban forest remnants. This expansion has drawn increasing attention because several of these fragments act as biodiversity refuges within a highly urbanized landscape. One emblematic example is Trianon Park (TP), a 4.8-ha Atlantic Forest remnant located in the city center, where the rapid increase of this palm has raised concerns about potential impacts on native recruitment and forest composition. Evidence gathered from one hectare of permanent plots monitored between 2017 and 2022 indicates substantial shifts in palm abundance and size structure, with rapid population growth prior to management actions.
Additional information provided by the São Paulo Secretariat for Green and Environment (SVMA administrative process: 2016-0.119.002-2) on individuals removed during management actions in 2021 allowed us to estimate aboveground biomass using the allometric model of Hughes et al. (1999). Together, these observations indicate how ornamental introductions may become structurally dominant in urban forests over time.
This trajectory was evident in Trianon Park, where Archontophoenix cunninghamiana expanded rapidly and reached densities of up to 391 palms ha^{-1}. Monitoring between 2017 and 2019 indicated densities of up to 391 palms ha^{-1}, values substantially higher than those typically reported for native palms in conserved Atlantic Forest sites.
Management actions implemented between 2021 and 2022 reduced abundance to 138 individuals ha^{-1} (≈65% reduction), with official records reporting the removal of 738 individuals. Across diameter classes, removed palms accumulated 3.3 tons of aboveground biomass, corresponding to an estimated 1.5–1.7 tons of carbon, with medium-to-large individuals accounting for most of this stock. This illustrates a recurrent management trade-off in invaded urban forests, where controlling dominant alien plants may be necessary to recover native ecological processes despite temporary reductions in biomass and carbon storage.
Similar invasion patterns of Archontophoenix cunninghamiana have been documented in other urban fragments of São Paulo (Petri et al., 2018), including a 10-ha protected area where the palm represented 22.5% of sampled individuals and occurred as seedlings in nearly all plots (Dislich et al., 2002). The demographic success of this palm is consistent with its high regenerative performance, with survival rates reaching 30% compared to only 3.5% for the native palm Euterpe edulis (Mengardo et al., 2012).
Despite repeated warnings about risks to native biodiversity, the species continues to be widely planted in ornamental contexts, increasing propagule pressure across urban

landscapes. Because Euterpe edulis plays a central ecological role as a food resource for birds and mammals and is already threatened by defaunation and homogenization processes (Galetti et al., 2013), further expansion of A. cunninghamiana may add competitive pressure to already vulnerable native palm populations.

Considering that the Atlantic Forest has lost over 87% of its original cover and that metropolitan forest edges connect to one of the largest remaining ecological corridors in southeastern Brazil (Marques & Grelle, 2021; Ribeiro et al., 2024), urban remnants may function as gateways for broader landscape-level invasion. From a management perspective, official data indicate substantial municipal expenditure for removal actions in TP in 2021 (approximately US$ 400,000; São Paulo 2022a). Although municipal instruments recommend eradication and control through management plans and official species lists (Ordinance No. 154/SVMA/2009), continued ornamental use may sustain propagule pressure.

In invasion ecology, propagule pressure is widely recognized as one of the strongest predictors of establishment success (Simberloff, 2009), particularly in urban environments where repeated ornamental planting continually replenishes seed sources (Davis et al., 2016). In this context, the persistent cultivation of Archontophoenix cunninghamiana across metropolitan landscapes may help explain its recurrent recruitment in forest remnants, even where local removal efforts are implemented. Urban parks and fragments embedded within densely populated areas may therefore function as recipient habitats constantly exposed to new propagules from surrounding gardens, streetscapes, and landscaped areas (Johnston-Bates et al., 2025).

The demographic pattern observed in Trianon Park may also reflect an early boom phase, characterized by rapid population increase following introduction into disturbed or resource-rich environments. Although the recent municipal removals substantially reduced local abundance, long-term monitoring will be necessary to determine whether this intervention represents a temporary suppression or a sustained population decline under continued management (Binny et al., 2021). Evaluating post-removal recruitment and seedling dynamics will be particularly important to assess population resilience and reinvasion risk (Torres et al., 2023).

Moreover, the success of this invasive palm relative to native species may additionally be linked to competitive advantages during regeneration, including high recruitment rates and greater juvenile survival previously reported for the species (Forey et al., 2023).

Such traits can progressively alter understory composition and recruitment pathways, especially where native palms such as Euterpe edulis already face pressures associated with habitat fragmentation and defaunation. Over time, these shifts may reduce ecological distinctiveness and favor more simplified communities dominated by a small number of disturbance-tolerant taxa (Zuñiga-Palacios et al., 2026).

These processes are closely associated with urban biotic homogenization, whereby floristic assemblages become increasingly similar across fragmented metropolitan landscapes. Consequently, the case documented in Trianon Park is unlikely to be isolated. Other urban forest remnants subjected to ornamental introductions, edge effects, and chronic disturbance may experience comparable trajectories, reinforcing the need for coordinated monitoring, prevention, and rapid-response strategies at the metropolitan scale (Kodym et al., 2025). Otherwise, this could be a serious silent danger to biodiversity.

These observations reinforce the need for coordinated preventive actions across metropolitan municipalities, particularly through monitoring, early removal strategies, and stricter regulation of high-risk ornamental species. Rather than representing an isolated case, the demographic expansion of Archontophoenix cunninghamiana illustrates how urban forest remnants can act as entry points for biological invasions within Atlantic Forest landscapes. Although this palm contributes to biomass accumulation, its competitive advantage over native species suggests an emerging ecological imbalance that demands long-term management and prevention efforts.

Acknowledgments

MLF thanks FAPESP (2019/24325-2 and 2024/15349-3) and the National Council for Scientific and Technological Development (CNPq) (Project 307185/2023-0) for financial support. The authors thank the Secretariat of Green and Environment of the city of São Paulo for data access and permission to work in urban forests (SVMA administrative process: 2016-0.119.002-2), and Luciano Ribeiro for providing technical information.

Authors’ Contributions

MLF and RL delineated the study and conceptualization; conducted the analyses; wrote and prepared the original draft; reviewed and edited the final version of the text.

Conflict of Interest

The authors declare that they have no competing interests.

Data Availability Statement

All data supporting the findings of this study are included in the manuscript.

Funding Information

Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) - 2019/24325-2 and 2024/15349-3.

Declaration of generative AI and AI-assisted technologies in the writing process

The authors did not use generative AI tools in the preparation of the manuscript.

References

Bello C, Cintra ALP, Barreto E, Vancine MH, Sobral-Souza T, Graham CH, et al., 2021. Environmental niche and functional role similarity between invasive and native palms in the Atlantic Forest. Biological Invasions 23: 741–754. doi: 10.1007/s10530-020-02400-8

Binny RN, Innes J, Fitzgerald N, Pech R, James A, Price R, et al., 2021. Long-term biodiversity trajectories for pest-managed ecological restorations: eradication vs. suppression. Ecological Monographs 91(2): e01439.

Boisvert-Marsh L, De Blois S. 2021. Unravelling potential northward migration pathways for tree species under climate change. Journal of Biogeography 48: 1088–1100. doi: 10.1111/jbi.14060

Bradshaw CJA, Hoskins AJ, Haubrock PJ, Cuthbert RN, Diagne C, Leroy B, et al., 2021. Detailed assessment of the reported economic costs of invasive species in Australia. NeoBiota 67: 511–550. doi: 10.3897/neobiota.67.58834

Cowie RH, Bouchet P, Fontaine B. 2022. The Sixth Mass Extinction: fact, fiction or speculation? Biological Reviews 97: 640–663. doi: 10.1111/brv.12816

Darwin C. 1859. On the Origin of Species. London, John Murray.

Davis AJ, Singh KK, Thill JC, Meentemeyer RK. 2016. Accounting for residential propagule pressure improves prediction of urban plant invasion. Ecosphere 7(3): e01232.

Dislich R, Kisser N, Pivello VR. 2002. A invasão de um fragmento florestal em São Paulo pela palmeira australiana Archontophoenix cunninghamiana. Brazilian Journal of Botany 25: 55–64. doi: 10.1590/S0100-84042002000100007

Ferreira ML, Silva JL, Pereira EE, Lamano-Ferreira APN. 2014. Litter fall production and decomposition in a fragment of secondary Atlantic Forest. Revista Árvore 38: 591–600. doi: 10.1590/S0100-67622014000400002

Ferreira ML, Oliveira NC, Cintra AAGF, Alvim DS, Lamano-Ferreira APN. 2021. Ecological implications of twentieth century reforestation programs for the urban forests of São Paulo. Ecological Processes 10: 72. doi: 10.1186/s13717-021-00342-9

Ferreira ML, Oliveira NC, Cintra AAGF, Moreira MS, Nakazato RK, Alvim DS. 2025. Urban Forests and Environmental Challenges in the Last Decades in Brazil: Insights for the National Urban Forestry Plan. Sustainable Development 33: 27–40. doi: 10.1002/sd.70234

Forey E, Galvin SD, Lowry JH, Gopaul S, Hanson G, Carboni M, et al., 2023. Alien palm invasion leads to selective biotic filtering of resident plant communities towards competitive functional traits. Biological Invasions 25(5): 1489–1508.

Galetti M, Guevara R, Côrtes MC, Fadini R, Von Matter S, Leite AB, et al., 2013. Functional extinction of birds drives rapid evolutionary changes in seed size. Science 340: 1086–1090. doi: 10.1126/science.1233774

Gentili R, Schaffner U, Martinoli A, Citterio S. 2021. Invasive alien species and biodiversity: impacts and management. Biodiversity 22: 1–3. doi: 10.1080/14888386.2021.1929484

Haubrock PJ, Cuthbert RN, Sundermann A, Diagne C, Golivets M, Courchamp F. 2021. Economic costs of invasive species in Germany. NeoBiota 67: 225–246. doi: 10.3897/neobiota.67.59502

Hughes RF, Kauffman JB, Jaramillo VJ. 1999. Biomass, carbon and nutrient dynamics of secondary forests in a humid tropical region of Mexico. Ecology 80: 1892–1907. doi: 10.1890/0012-9658(1999)080[1892:BCANDO]2.0.CO;2

Johnston-Bates J, Capon SJ, Castley JG. 2025. Propagule bank dynamics in urban subtropical forest remnants: edge effects, fragmentation and plant invasion. Urban Forestry & Urban Greening 103: 128563.

Joly CA, Assis MA, Bernacci LC, Tamashiro JY, Campos MCR, Gomes JAP, et al., 2012. Florística e fitossociologia em parcelas permanentes da Mata Atlântica. Biota Neotropica 12: 1–20. doi: 10.1590/S1676-06032012000200001

Kodym A, Lapin K, Sanyal D. 2025. Ecological connectivity in urban and semi-urban forests. In: Lapin K, Oettel J, Braun M, Konrad H. (eds) Ecological connectivity of forest ecosystems. Cham, Springer Nature Switzerland. Pp. 365-381.

Lokatis S, Jeschke JM. 2022. Urban biotic homogenization. Ecological Applications 32: e02534. doi: 10.1002/eap.2534

Lowry BJ, Lowry JH, Jarvis KJ, Keppel G, Thaman RR. 2020. Spatial patterns of invasive woody plants in urban areas. Urban Forestry & Urban Greening 48: 126516. doi: 10.1016/j.ufug.2019.126516

Marchiori NM, Rocha-Urso T, Dislich R. 2016. Tree community composition and aboveground biomass in a secondary Atlantic Forest. Cerne 22: 33–42. doi: 10.1590/01047760201622012066

Marques MC, Grelle CEV. 2021. The Atlantic Forest. Cham, Springer. doi: 10.1007/978-3-030-55322-7

Martins APG, Ferreira ML, Alvim DS, Lamano-Ferreira APN. 2021. Infraestrutura verde para monitorar poluição atmosférica. Estudos Avançados 35: 123–138. doi: 10.1590/s0103-4014.2021.35101.008

Matos DMS, Pivello VR. 2009. O impacto das plantas invasoras nos recursos naturais. Ciência e Cultura 61: 27–30.

Mengardo AL, Pivello VR, Dislich R. 2012. Comparing the establishment of an invasive and an endemic palm. Plant Ecology & Diversity 5: 345–352. doi: 10.1080/17550874.2012.680105

Pepe M, Crescente MF, Varone L. 2022. Effect of water stress on physiological and morphological leaf traits: A comparison among the three widely-spread invasive alien species Ailanthus altissima, Phytolacca americana, and Robinia pseudoacacia. Plants 11: 899. doi: 10.3390/plants11070899

Pereira MAG, Domingos M, Silva EA, Aragaki S, Ramon M, Camargo PB, et al., 2022. Isotopic composition (δ13C and δ15N) in the soil-plant system of subtropical urban forests. Science of the Total Environment 851: 158052. doi: 10.1016/j.scitotenv.2022.158052

Petri L, Aragaki S, Gomes EPC. 2018. Management priorities for exotic plants in an urban Atlantic Forest reserve. Acta Botanica Brasilica 32: 631–641. doi: 10.1590/0102-33062017abb0317

Ramon M, Ribeiro AP, Sawamura Theophilo CY, Moreira EG, Camargo PB, et al., 2023. Assessment of four urban forest as environmental indicator of air quality: a study in a Brazilian megacity. Urban Ecosystems 26: 197–207. doi: 10.1007/s11252-022-01296-7

Ramon M, Lafortezza R, Ribeiro AP, Camargo PB, Domingos M, Gomes EPC, et al., 2024. Carbon and nitrogen stock in soils of subtropical urban forests: Isotopic δ13C and δ15N indicators for nature-based solutions in a megacity. Ecological Indicators 160: 111743. doi: 10.1016/j.ecolind.2024.111743

Ribeiro JVM, Mendes TSG, Simões SJC, Martins IM, Ferreira CC, Camarinha PIM, et al., 2024. Planning and implementing ecological corridors in the southeast Atlantic Forest:

Challenges and opportunities. Anais da Academia Brasileira de Ciências 96: e20230768. doi: 10.1590/0001-3765202420230768

São Paulo (Município). 2022a. Reforma no Parque Trianon valoriza Mata Atlântica. Available at: <https://www.prefeitura.sp.gov.br>.

Shiba M, Kobayashi N, Harada S, Fukuda T. 2024. Decrease in wind stress leads to an increase in the above ground morphology and number of seeds of an invasive alien species, Bidens pilosa (Asteraceae). Frontiers in Plant Science 15: 1445437. doi: 10.3389/fpls.2024.1445437

Solarz W, Najberek K, Tokarska-Guzik B, Pietrzyk-Kaszyńska A. 2023. Climate change as a factor enhancing the invasiveness of alien species. Environmental & Socio-economic Studies 11: 36–48. doi: 10.2478/environ-2023-0022

Sołtysiak J. 2020. Urban heat island and invasive taxa distribution. Ecological Questions 31: 27–34. doi: 10.12775/EQ.2020.010

Te Beest M, Cromsigt JPGM, Ngobese J, Olff H. 2012. Managing invasions at the cost of native habitat? An experimental test of the impact of fire on the invasion of Chromolaena odorata in a South African savanna. Biological Invasions 14: 607–618. doi: 10.1007/s10530-011-0095-x

Torres A, Morán-López T, Rodriguez-Cabal MA, Núñez MA. 2023. Timing of invasive species removal influences nonnative biotic resistance and trajectories of community reassembly. Journal of Ecology 111(11): 2342–2356.

Trisos CH, Merow C, Pigot AL. 2020. The projected timing of abrupt ecological disruption from climate change. Nature 580: 496–501. doi: 10.1038/s41586-020-2189-9

Zuñiga-Palacios J, Zuria I, Moreno CE. 2026. Global Patterns and Drivers of Urban Biotic Homogenization: A Meta-Analysis. Global Ecology and Biogeography 35(3): e70219.