

Forested Wetlands in the Congo Basin: Patterns and Processes



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Summary

This trip comprised a four-week trip to the Nouabalé-Ndoki National Park in the northern Republic of Congo (Brazzaville). The goal was to establish plots in the swamps found alongside the rivers and streams of the region to improve our understanding of the plant biodiversity and ecological dynamics of these forests. We spent one week each at Goualougou, Ndoki Formation, and Djéké, during which we established three new plots and revisited one plot established last year. We measured 560 trees from 52 species, preserved 140 herbarium specimens, and measured water chemistry and collected soil samples from seven locations.

Background

The Congo Basin is the world's second largest river basin and supports the second largest contiguous tropical forest after the Amazon, including some of the largest areas of intact tropical forest anywhere in the world (Grantham et al., 2020). Wetlands cover an estimated 32% of the Congo Basin, an area of 359,556 km² (Bwangoy et al., 2010), but most forest research in the Congo has focused on *terra firme* forest, and especially on commercially significant species (Chervier et al., 2024; Fayolle et al., 2012; Rejou-Mechain et al., 2021). Early work by Lebrun and Gilbert (1954) and Évrard (1968) identified the heterogeneity of forested wetlands in the Congo Basin and recognized the influence of flooding regime, substrate, and fluvial geomorphology on forest ecology. After these preliminary studies, little additional research was done in the area for decades (Campbell, 2005). The discovery in 2017 of the world's largest tropical peatland in the Congo Basin (Dargie et al., 2017) prompted renewed interest in the ecology of forested wetlands. Crezee (2022) and Dargie et al. (2017) documented several distinct peat-forming forested wetland types with different vegetation types, and Ifo et al. (2018) identified two non-peat-forming types of seasonally flooded forest. The work of Lebrun and Gilbert (1954) and Évrard (1968) suggests that considerably more diversity exists than has been sampled by these modern studies, and more work is needed to understand forested wet, especially on non-peat forming wetlands (Ifo et al., 2018).

Forested wetlands are important interfaces between terrestrial and aquatic ecosystems, and provide a variety of important ecosystem services (Naiman & Décamps, 1997). Understanding the extent and diversity of these ecosystems in the Congo Basin is relevant for wildlife conservation, carbon cycling, and land management. Forested wetlands in the region are frequented by forest elephants (*Loxodonta africana cyclotis*), gorillas (*Gorilla gorilla gorilla*), chimpanzees (*Pan troglodytes*), and other endangered megafauna (Fay & Agnagna, 2008), but these animals utilize different wetland forest types in different ways. The Congo Basin also plays an important role in global carbon cycle. Central African forests of all types have some of the highest aboveground biomass (AGB) of any tropical forests with an average of 429 Mg ha⁻¹ (Lewis et al., 2013). Peat deposits associated with forested wetlands in the Congo Basin sequester an average of 1,741 Mg ha⁻¹ of carbon (Crezee, 2022), equivalent to 3 years of global emissions (Dargie et al., 2017). Like all wetlands and riparian systems, forested wetlands in the Congo basin are threatened by climate change driven changes in precipitation patterns (IPCC, 2023), particularly as increased seasonality and severity of precipitation events will affect flooding cycles (OFAC/CBFP). More direct human impacts include road building, which has the potential to alter hydrology (Shuldiner & Cope, 1979) as well as facilitating access to, and exploitation of, forest resources (Rainey et al., 2009; Wilkie et al., 2000). In spite of their importance to wildlife habitat and other ecosystem services, our understanding of the floristics and phytoecology of forested wetlands remains limited.

Aims

The aims of this trip were to:

1. Continue my investigations of the structure and diversity of forested wetlands in the area by establishing additional plots to complement those which I established in the area 2024.
2. Improve our understanding of the floristics of these swamp forests through general collecting of botanical specimens.
3. Explore potential abiotic drivers of forest composition by collecting soil samples and making in-situ measurements of water quality.

Data Collection

Study Area

This research was conducted in the area south of Nouabalé-Ndoki National Park in the Republic of Congo (2°05'–3°03'N, 16°51'–16°56'E). Plots were established in swamp forests near three camps: Goualougou, Ndoki Formation, and Djéké (Figure 1).

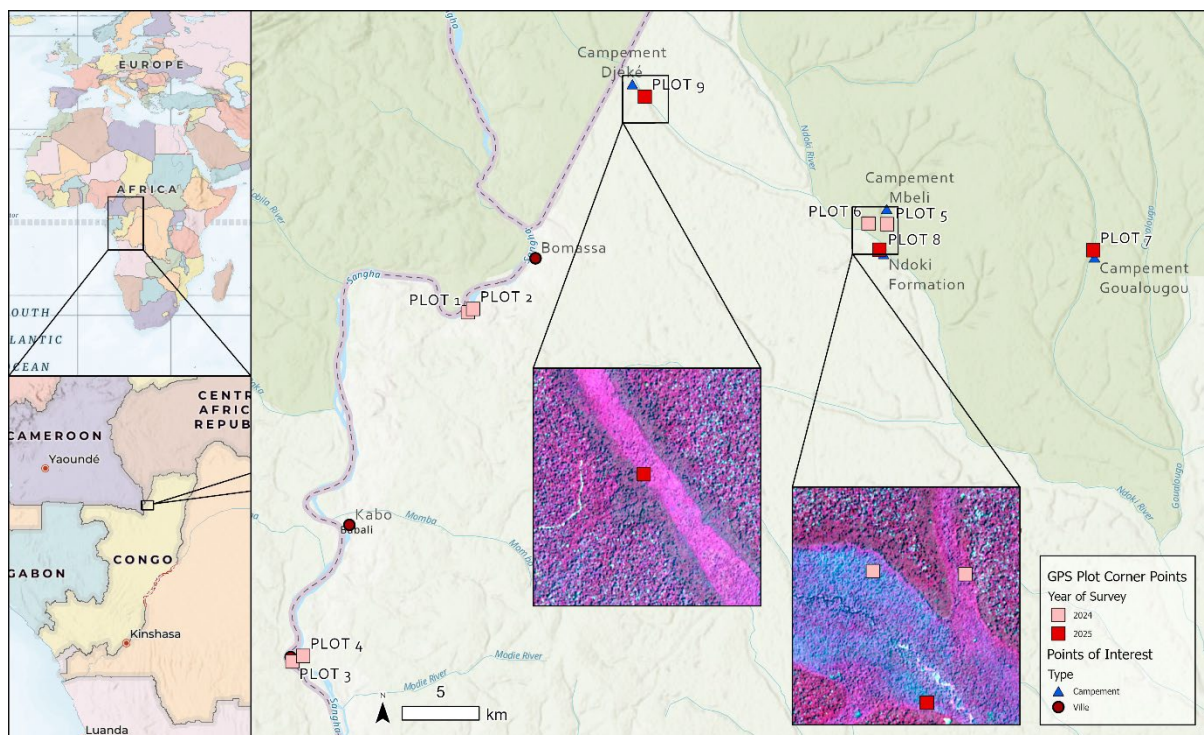


Figure 1: Map of my study area in the northern Republic of Congo at the southern edge of the Nouabalé Ndoki National Park. Plots highlighted in red are those newly established in 2025, adjacent to Goualougou, Ndoki Formation and Djéké. The inset maps show a colour-infrared composite satellite image which emphasizes the heterogeneity of forest cover.

Study Period

This research trip ran from July 15 to August 15 2025.

Research Team

The team consisted of myself (Galen Costomiris), Josérald Mamboueni and Davy Koni, field technicians employed by Wildlife Conservation Society-Congo (WCS-Congo), four local guides: Ahmed Bouba, Itoua Mongembe, Kuru Bakembe, Riche Yoka Odilon, and my supervisor Dr. David Harris.



Figure 2: The research team. Back row, L-R: Galen Costomiris, Davy Koni, Riche Yoka Odilon, Ahmed Bouba, Joseràld Mamboueni, David Harris. Front row, L-R: Kuru Bakembe, Itoua Mongembe.

Methodology

We established three new plots in permanently flooded forested wetlands along the Goualougou, Ndoki, and Djéké rivers. Plots were positioned by manually delineating areas of interest on the floodplains and generating random points within these polygons. All plots were $\frac{1}{4}$ ha (50 x 50 m). Within this $\frac{1}{4}$ hectare, we measured and identified all trees above 10 cm DBH (Fig. 3). To better sample large trees, which contribute disproportionately to biomass (Harris et al., 2021), a 1 ha super-plot was nested around the southwest corner of the $\frac{1}{4}$ ha plots in which only trees above 70 cm DBH were measured. To capture young recruits and smaller understory trees, a $\frac{1}{10}$ ha subplot with a minimum diameter threshold of 2.5 cm was established at the southwest corner. All trees were marked with aluminium tags, diameter measured and identified to species. For trees which could not be positively identified in the field, voucher specimens were taken and preserved at the herbaria in Brazzaville and Edinburgh (E). Lianas above 2.5 cm in diameter were counted (but not measured or identified) in a 20 x 50 m subplot (Fig. 4). We also revisited one plot which we established in 2024 but which was incompletely surveyed. In 2025 we completed the 1 ha plot of large trees and the liana survey.

In each plot we collected five 30 cm deep soil cores, which were homogenized and dried for transport back to Edinburgh. In the lab we performed nutrient (C, N, P, exchangeable cations) and particle size analyses. Within each plot, the electrical conductivity, pH, and turbidity of the floodwaters were measured with a handheld probe (Hanna Instruments HI 98129).

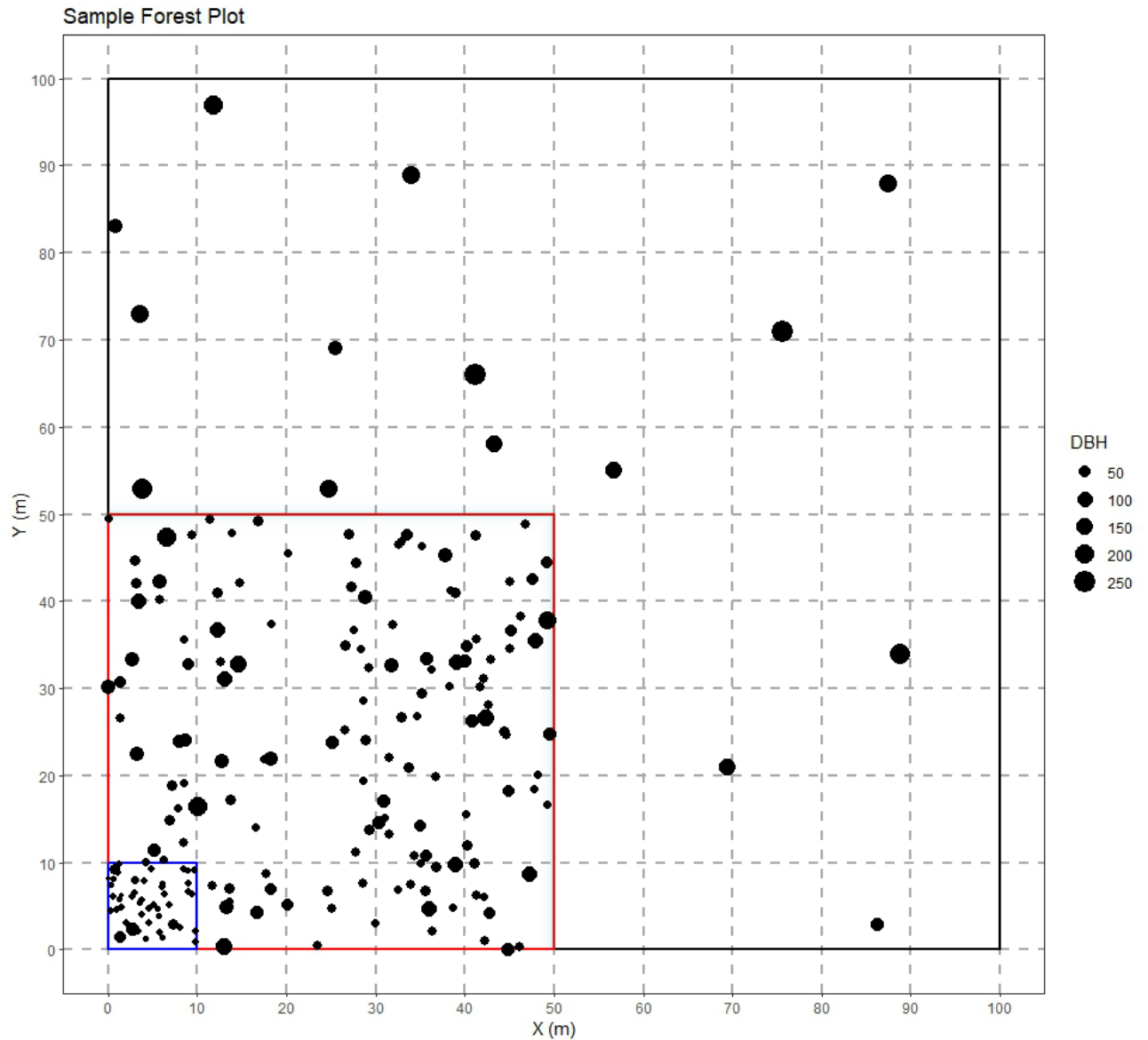


Figure 3: Forest plot layout visualized using a randomly generated dataset.



Figure 4: Josérald Mamboueni (L) and Galen Costomiris (R) in one of our forest plots on the Djéké river. Note the abundance of large vines.

Outcomes

We established three new plots and revisited one plot established last year. We measured 560 trees from 52 species, preserved 140 herbarium specimens, and measured water chemistry and collected soil samples from seven locations. Preliminary analyses support delineating three types of forested wetland which are differentiated by flooding depth and duration, soil type, and tree species composition. Each of these forests is dominated by a community of specialist tree species, most of which do not occur in any other forest type.

Next Steps

Combined with the plots I established last year these data represent one of the largest plot datasets from forested wetlands in the region. Soil and water samples are currently undergoing analysis in the School of GeoSciences laboratory. I am currently in the process of drafting a manuscript based on these data, which I hope will provide some novel insights into a poorly understood ecosystem.

References

- Bwangoy, J.-R. B., Hansen, M. C., Roy, D. P., Grandi, G. D., & Justice, C. O. (2010). Wetland mapping in the Congo Basin using optical and radar remotely sensed data and derived topographical indices. *Remote Sensing of Environment*, 114(1), 73-86. <https://doi.org/10.1016/j.rse.2009.08.004>
- Campbell, D. (2005). The Congo River basin. In L. H. Fraser & P. A. Keddy (Eds.), *The World's Largest Wetlands: Ecology and Conservation*. Cambridge University Press.
- Chervier, C., Ximenes, A. C., Mihigo, B.-P. N., & Doumenge, C. (2024). Impact of industrial logging concession on deforestation and forest degradation in the DRC. *World Development*, 173, 106393.
- Crezee, B. (2022). *Spatial distribution, carbon stocks and diversity of peat swamp forests in the central Congo Basin* [University of Leeds].
- Dargie, G. C., Lewis, S. L., Lawson, I. T., Mitchard, E. T., Page, S. E., Bocko, Y. E., & Ifo, S. A. (2017). Age, extent and carbon storage of the central Congo Basin peatland complex. *Nature*, 542(7639), 86-90. <https://doi.org/10.1038/nature21048>
- Évrard, C. (1968). *Recherches écologiques sur le peuplement forestier des sols hydromorphes de la cuvette central congolaise*. INEAC.
- Fay, J. M., & Agnagna, M. (2008). A population survey of forest elephants (*Loxodonta africana cyclotis*) in northern Congo. *African Journal of Ecology*, 29(3), 177-187. <https://doi.org/10.1111/j.1365-2028.1991.tb01000.x>
- Fayolle, A., Engelbrecht, B., Freycon, V., Mortier, F., Swaine, M., Rejou-Mechain, M., Doucet, J. L., Fauvet, N., Cornu, G., & Gourlet-Fleury, S. (2012). Geological substrates shape tree species and trait distributions in African moist forests. *PloS one*, 7(8), e42381. <https://doi.org/10.1371/journal.pone.0042381>
- Grantham, H. S., Shapiro, A., Bonfils, D., Gond, V., Goldman, E., Maisels, F., Plumptre, A. J., Rayden, T., Robinson, J. G., Strindberg, S., Stokes, E., Tulloch, A. I. T. T., Watson, J. E. M., Williams, L., & Rickenbach, O. (2020). Spatial priorities for conserving the most intact biodiverse forests within Central Africa. *Environmental Research Letters*, 15(9). <https://doi.org/10.1088/1748-9326/ab9fae>
- Harris, D. J., Ndolo Ebika, S. T., Sanz, C. M., Madingou, M. P. N., & Morgan, D. B. (2021). Large trees in tropical rain forests require big plots. *Plants, People, Planet*, 3(3), 282-294. <https://doi.org/10.1002/ppp3.10194>
- Ifo, S. A., Binsangou, S., Ibocko Ngala, L., Madingou, M., & Cuni-Sanchez, A. (2018). Seasonally flooded, and terra firme in northern Congo: Insights on their structure, diversity and biomass. *African Journal of Ecology*, 57(1), 92-103. <https://doi.org/10.1111/aje.12555>
- IPCC. (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*.
- Lebrun, J., & Gilbert, G. (1954). *Une classification écologique des forêts du Congo* (Vol. 63). INEAC Bruxelles, Belgique.
- Lewis, S. L., Sonke, B., Sunderland, T., Begne, S. K., Lopez-Gonzalez, G., van der Heijden, G. M., Phillips, O. L., Affum-Baffoe, K., Baker, T. R., Banin, L., Bastin, J. F., Beeckman, H., Boeckx, P., Bogaert, J., De Canniere, C., Chezeaux, E., Clark, C. J., Collins, M., Djablletey, G., . . . Zemagho, L. (2013). Above-ground biomass and structure of 260 African tropical forests. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, 368(1625), 20120295. <https://doi.org/10.1098/rstb.2012.0295>
- Naiman, R. J., & Décamps, H. (1997). The Ecology of Interfaces: Riparian Zones. *Annual Review of Ecological Systems*, 28, 621-658.
- OFAC/CBFP. (2008). *The Forests of the Congo Basin - State of the Forest 2008*. Publications Office of the European Union.

- Rainey, H. J., Iyenguet, F. C., Malanda, G.-A. F., Madzoké, B., Santos, D. D., Stokes, E. J., Maisels, F., & Strindberg, S. (2009). Survey of Raphia swamp forest, Republic of Congo, indicates high densities of Critically Endangered western lowland gorillas *Gorilla gorilla gorilla*. *Oryx*, 44(01). <https://doi.org/10.1017/s003060530999010x>
- Rejou-Mechain, M., Mortier, F., Bastin, J. F., Cornu, G., Barbier, N., Bayol, N., Benedet, F., Bry, X., Dauby, G., Deblauwe, V., Doucet, J. L., Doumenge, C., Fayolle, A., Garcia, C., Kibambe Lubamba, J. P., Loumeto, J. J., Ngomanda, A., Ploton, P., Sonke, B., . . . Gourlet-Fleury, S. (2021). Unveiling African rainforest composition and vulnerability to global change. *Nature*, 593(7857), 90-94. <https://doi.org/10.1038/s41586-021-03483-6>
- Shuldiner, P., & Cope, F. (1979). Ecological effects of highway fills on wetlands: Examples from the field. *Journal of the Transportation Research Board*, 736, 29-37.
- Wilkie, D., Shaw, E., Rotberg, F., Morelli, G., & Auzel, P. (2000). Roads, Development, and Conservation in the Congo Basin. *Conserv Biol*, 14(6), 1614-1622. <https://doi.org/10.1111/j.1523-1739.2000.99102.x>