# A dendroecological comparison of two Miombo woodlands under differing anthropogenic disturbances in Zambia

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## PROJECT BACKGROUND

**Dendrochronological data is lacking in tropical forested regions**, especially the African continent, due to a lack of existing dendrochronological labs for training and research and the added difficulty of indistinguishable annual ring boundaries in tropical species[1,2]. In 2021, **we held the first ever dendrochronological field school in Africa** based at Copperbelt University in Kitwe, Zambia. The **field school trained graduate students, faculty members, professionals and others from 8 nations** in dendrochronological methods. We pursued three separate group projects with different foci (ecology and climatology).

## INTRODUCTION

- The Miombo woodlands of interior Africa are fire adapted systems dominated by an open canopy of *Brachystegia* spp., *Julbernardia* spp., and *Isoberlina* spp.[3]
- These ecosystems are threatened due to deforestation, habitat fragmentation, and impacts from climate change[4]
- In Zambia, they are further threatened by the rapidly growing mining industry and fire exclusion practices where habitat remains[3]
- These different practices lead to different outcomes in species composition and therefore affect ecosystem health, resilience, and service production[5]

## OBJECTIVES

- **Determine and compare stand structure** (stems/ha) at two sites: an old-growth but fire excluded Miombo woodland and a degraded, recently logged Miombo woodland
- **Explore dendrochronological potential** of multiple tropical species **and construct chronologies** where possible using samples from three sites

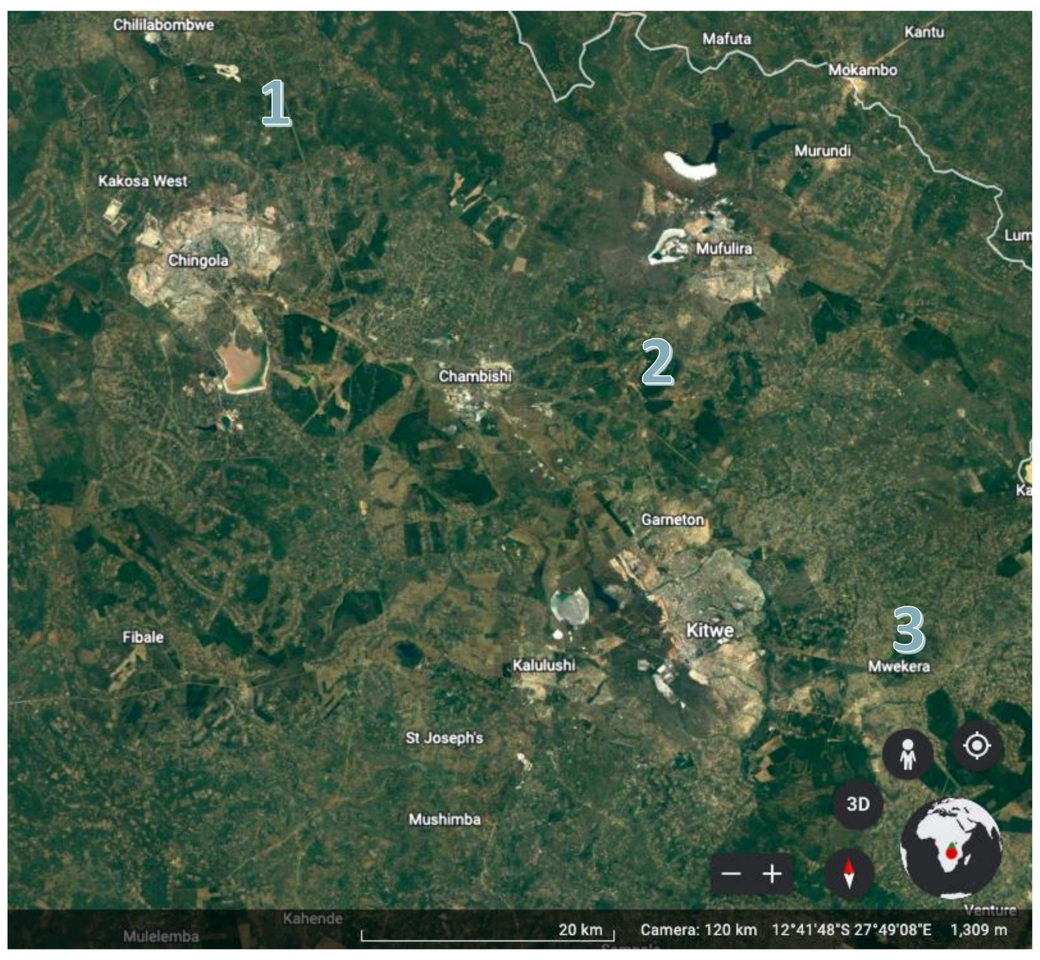



**Figure 1**. Site location map. 1. Hippo Pool Forest Reserve near Chingola (degraded and logged woodland near mine). 2. African Explosives Limited (AEL) site near Mufulira (protected, old-growth, but fire excluded woodland). 3. Zambia Forestry College near Mwekera (site for additional sampling of *Brachystegia boehmii* and *Julbernardia paniculata*). Map source: Google Earth Pro.

## METHODS

- Sites were selected to achieve the specific goals related to individual projects: **(1) a degraded and logged Miombo woodland near a mine, (2) a protected, old-growth, but fire excluded Miombo woodland**, and **(3) a managed Miombo woodland** for additional sampling (Figure 1)
- At Sites 1 and 2, we used modified variable area transects[6] to estimate tree density by species. At site 2, we estimated tree density by species and by life stage and form (seedling, seedling multi-stem, juvenile, juvenile multi-stem, mature, and mature multi-stem)
- At Site 1 and 2, we sampled all trees encountered within plots with dbh > 10 cm, for a total of 20 trees (2 cores/tree)
- At Site 3, we collected additional cores (20 trees, 2 cores/tree) from *Julbernardia paniculata* and *Brachystegia boehmii* to aid in chronology development at the other sites
- Cores were processed using standard methods[7] – mounted, sanded using progressively finer grit, and then digitized (2400 dpi)
  - Tree rings for *Julbernardia paniculata* and *Brachystegia boehmii* were measured to the nearest 0.001 mm using CooRecorder[8] and crossdating was verified using COFECHA[9]
  - All other species were visually crossdated but not measured due to time constraints
- We used generalized linear mixed effects models to estimate tree density at Site 1 and 2.

## RESULTS

**Table 1**. Chronology statistics for *Julbernardia paniculata*

| Species | No. of cores in final chronology | Age Range | IC | MS | Mean length of series |
|---|---|---|---|---|---|
| Julbernardia paniculata | 16 | 1889-2021 | 0.272 | 0.508 | 91 |

- **At Site 1, we recorded only 1 species**, (*Albizia adianthifolia*), and **at Site 2, we recorded 18 species** (Figure 2).
- We found **tree density at Site 1 was 1,410 stems/ha** (monotypic)
  - At Site 1, density of *A. adianthifolia* was highest in seedlings, followed by juvenile multi-stem individuals (Figure 3).
- **At Site 2, tree density was 9,670 stems/ha overall.**
  - ***Julbernardia paniculata* was the most dominant species**, and ***A. adianthifolia*** had only 260 stems/ha, **81% less than Site 1**.
- **Most of the species appeared to produce annual ring boundaries** (with thin terminal parenchyma) although similar looking fibrous bands made crossdating challenging (Figure 4)
- We generated **chronologies for 2 species**: *Julbernardia paniculata* (Table 1) and *Brachystegia boehmii* (See Maxwell et al., this session)
- **Pith estimates from all species at Site 2 suggest changing species composition associated with** time of site acquisition and subsequent **fire exclusion** (Figure 5)

**Figure 5**. Species composition by establishment date at Site 1.

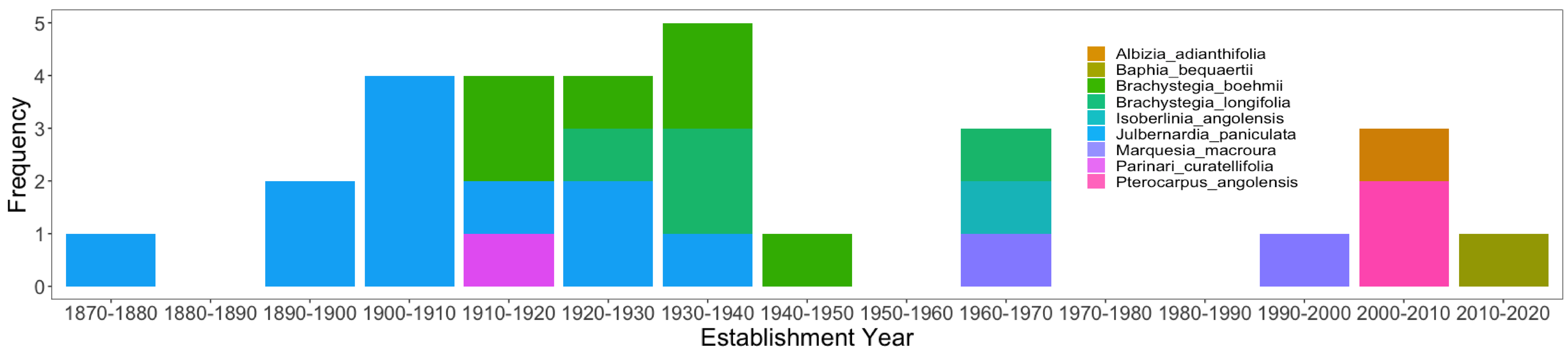



**Figure 2**. Tree density by species in trees/ha from Site 2

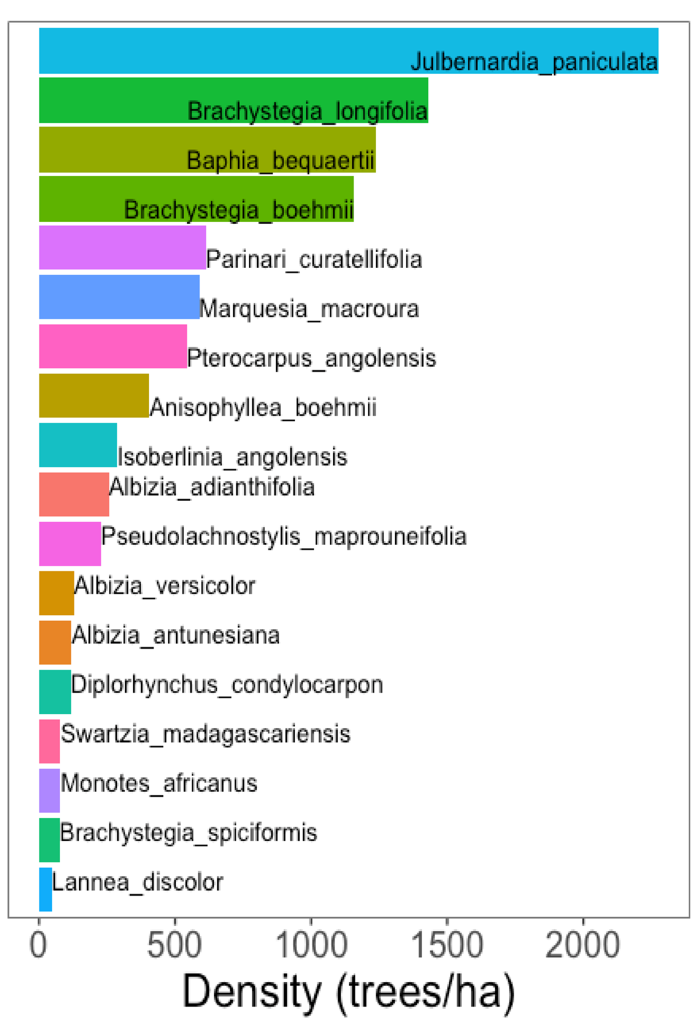
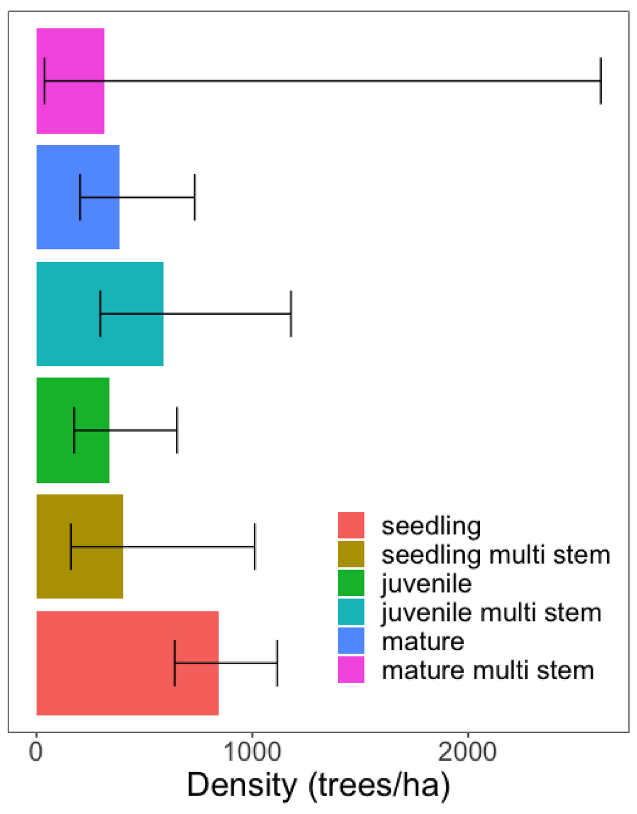



**Figure 3 (below)**. Tree density of *Albizia adianthifolia* in trees/ha by life-stage and form from Site 1



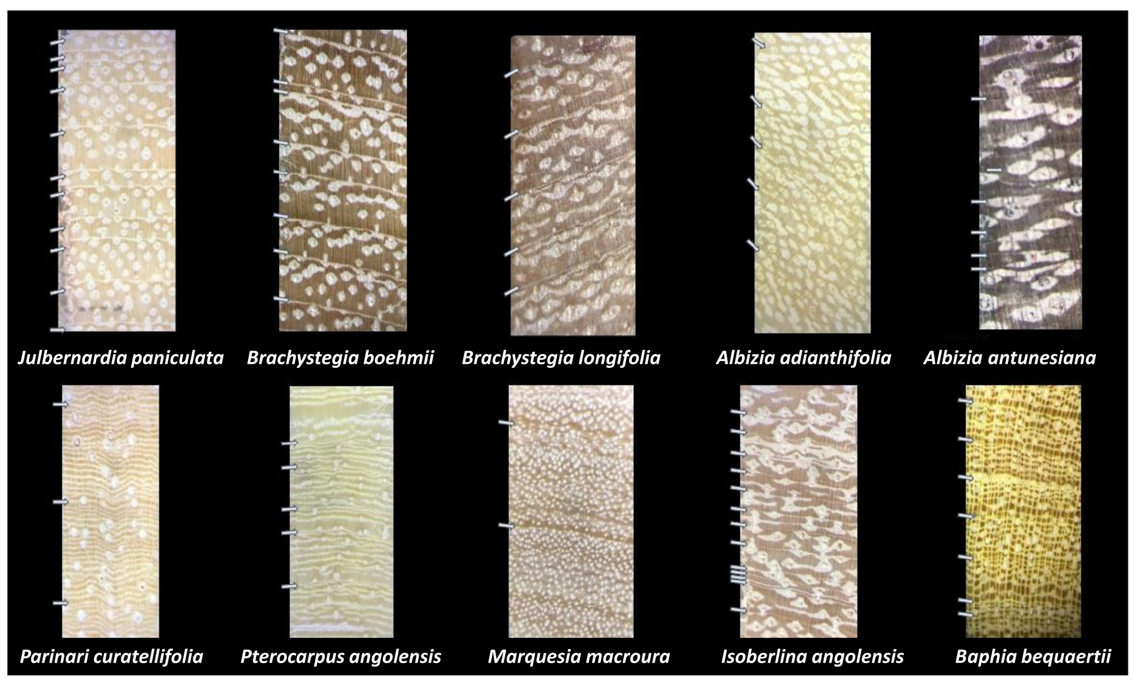




**Figure 4**. Ring structure of the ten arboreal species that we sampled. Figure reproduced from Speer et al. (2022, In Review)

## CONCLUSIONS

- Although we were unable to produce a chronology for *Albizia adianthifolia* and other species, it appeared that annual ring formation was possible and could be identified in older trees from a site with a common signal
- The differing anthropogenic disturbances lead to dramatically different species composition – a monoculture of an early successional species (*A. adianthifolia*) and a shifting closed canopy degraded woodland
- The Miombo woodlands of interior Africa are threatened by anthropogenic activities that reduce biodiversity and decrease ecosystem resiliency and the production of ecosystem services

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