15-year dynamics of miombo woodlands

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First Niassa Special Reserve Science Meeting and Miombo Network Meeting: from science to miombo woodlands management

Maputo, 3-4 June 2021

Introduction

Forest dynamics is the mechanism through which forests change their structure, composition and operations in response to various factors, including disturbances (Lamprecht, 1990).

Fires, elephants, environmental variables and anthropogenetic activities are amongst the most influential factors affecting significantly the dynamics of miombo ecosystems.

A thorough knowledge of these factors, their interactions and effects on vegetation is crucial for miombo ecosystems management, and can facilitate interpreting the process of their development over time.

Conservation areas are key to regulate the use of resources and conserve biodiversity

AIM

The aim of this study was to assess the factors affecting the dynamics of miombo ecosystem in Niassa Special Reserve.

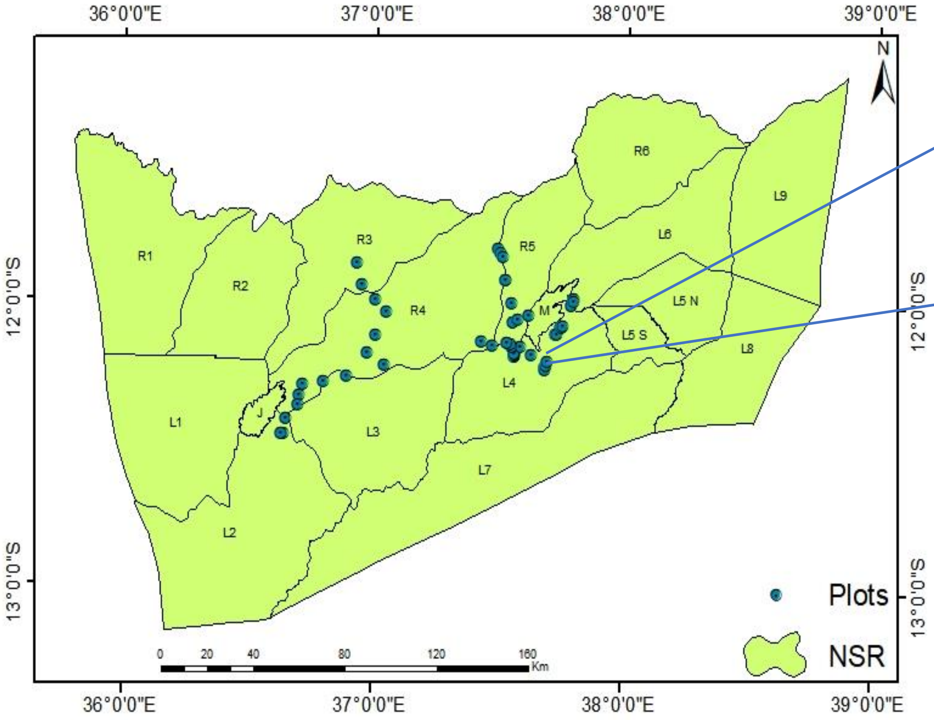
Specific Objectives:

1. To determine carbon stocks, recruitment rates, mortality and growth between 2005 and 2019
2. To analyze the relationship between vegetation dynamics and environmental factors
3. To predict the miombo woodlands condition for the year 2033, through a transition matrix

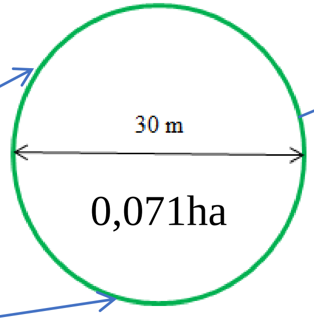
Methodology

50 permanent plots: Since 2004

Type: Permanent



1. Permanent plots established along the fire frequency gradient



Fire frequency classes	
Low	2_3
Medium	4_5
High	≥ 7

Estimated parameters

1. Recruitment and Mortality Rates

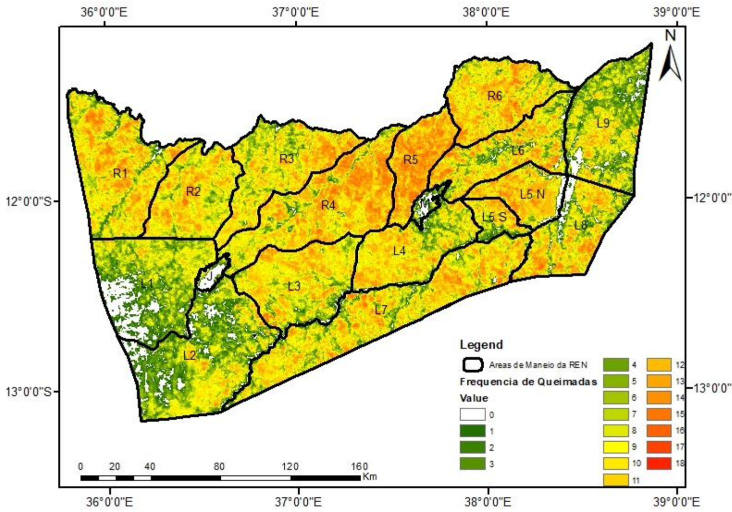
2. Annual Periodic Increment

3. Biomass and carbon stock

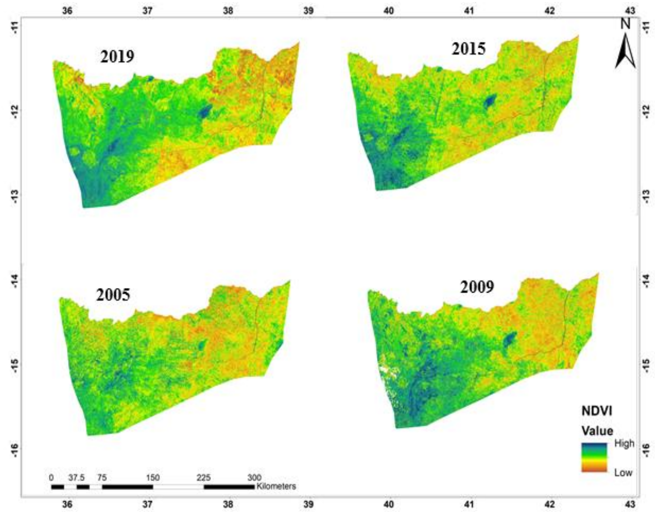
Methodology

1. Correlation & Regression

1. **Spatial frequency distribution of fires (2005-2019)**



2. Spatial distribution of NDVI



Other factors mapped

3. Density of elephants (ind/Km^2)
4. Distance to road (m)
5. Severity of fires ( ) NBR
6. Precipitation (mm)
7. Temperature (^{o}C)

Projection of the diametric distribution

4. TRANSITION MATRIX

Yt + Δt = Gt x Yt + It

$$\begin{bmatrix} Y_{1t+\Delta t} \\ Y_{2t+\Delta t} \\ Y_{3t+\Delta t} \\ \vdots \\ \vdots \\ \vdots \\ Y_{nt+\Delta t} \end{bmatrix} = \begin{bmatrix} a_1 & 0 & 0 & \cdots & \cdots & \cdots & 0 \\ b_2 & a_2 & 0 & \cdots & \cdots & \cdots & 0 \\ c_3 & b_3 & a_3 & \cdots & \cdots & \cdots & 0 \\ 0 & c_4 & b_4 & \cdots & \cdots & \cdots & 0 \\ 0 & 0 & c_5 & \cdots & \cdots & \cdots & 0 \\ \vdots & \vdots & \vdots & \ddots & \ddots & \ddots & \vdots \\ 0 & 0 & 0 & \cdots & c_n & b_n & a_n \end{bmatrix} * \begin{bmatrix} Y_{1t} \\ Y_{2t} \\ Y_{3t} \\ \vdots \\ \vdots \\ \vdots \\ Y_{nt} \end{bmatrix} + \begin{bmatrix} I_{1t} \\ I_{2t} \\ I_{3t} \\ \vdots \\ \vdots \\ \vdots \\ I_{nt} \end{bmatrix}$$

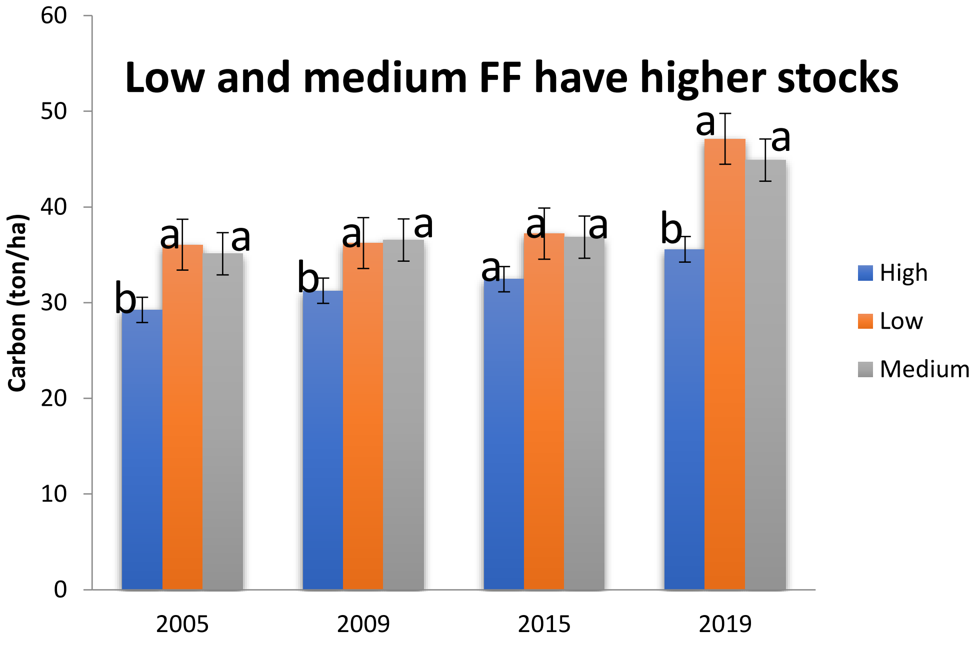
Assessment `accuracy projection

Kolmogorov – Smirnov test

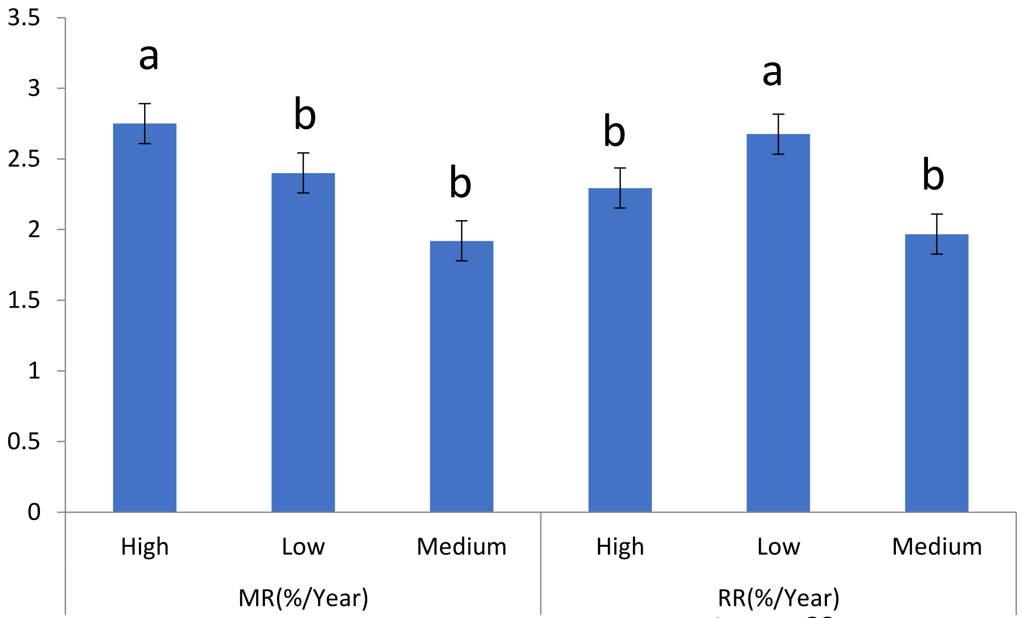
Results

Vegetation dynamics (2005-2019)

Estimated carbon values (mean ± standard error)



Mortality and recruitment rates at NSR



High FF => > Mortality rate

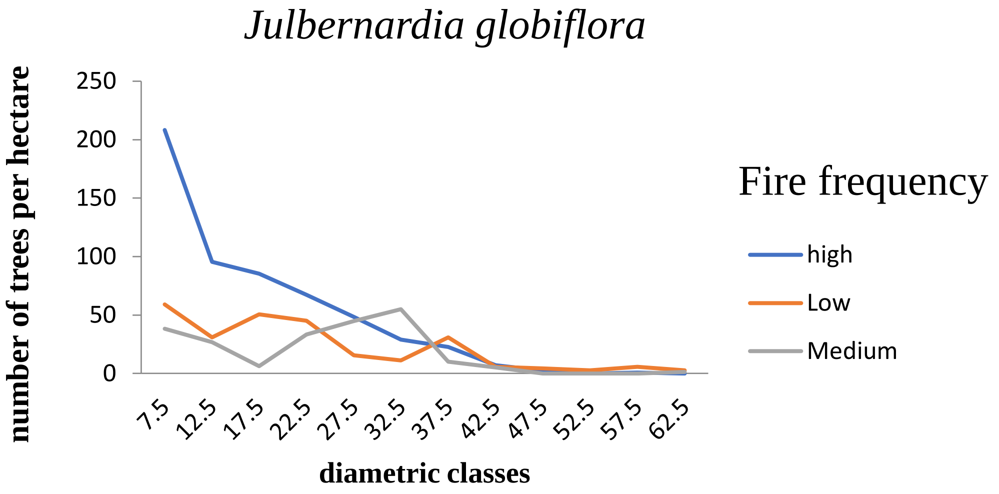
No major effects on recruitment

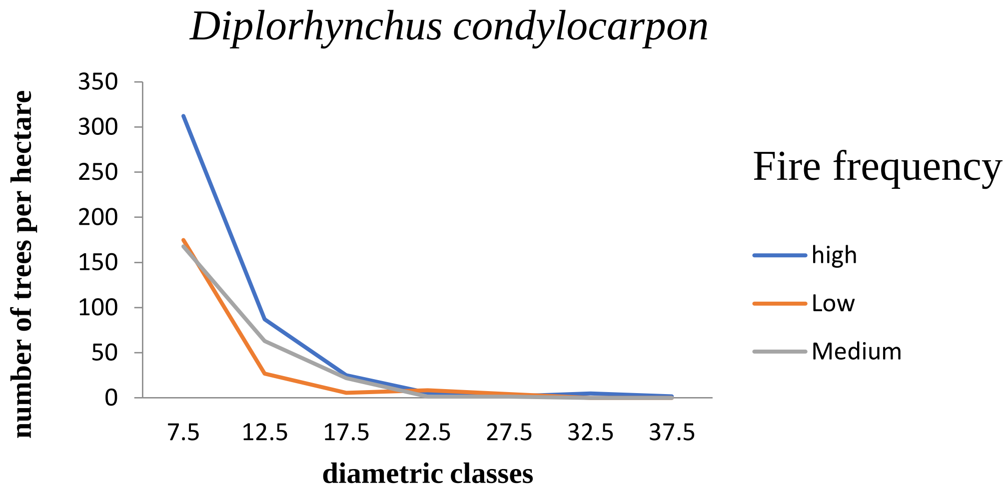
Table2. Annual periodic increments (mean ± standard error) of carbon and Dbh

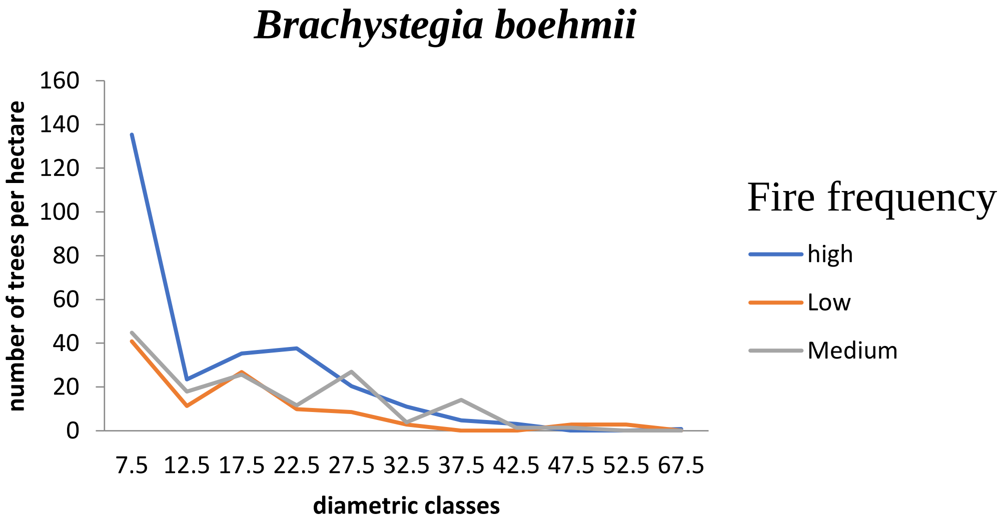
High FF reduces growth and C accumulation

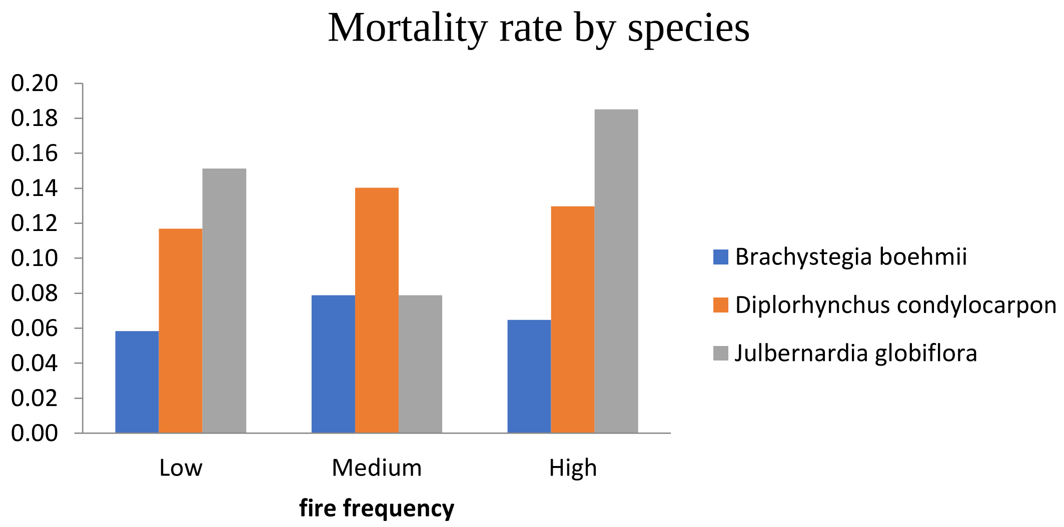
Parameter	Fire Frequency			
	High	Low	Medium	Average
API in Dbh (cm/year)	0,17 ± 0,02^{b}	0,33 ± 0,06^{a}	0,24± 0,04^{ab}	0,25 ± 0,04
API in Carbon (t/ha/year)	0,15± 0,02^{b}	0,48 ± 0,15^{a}	0,28 ± 0,06^{ab}	0,30± 0,1

Effects of fires at the species level









Factors affecting the vegetation dynamics

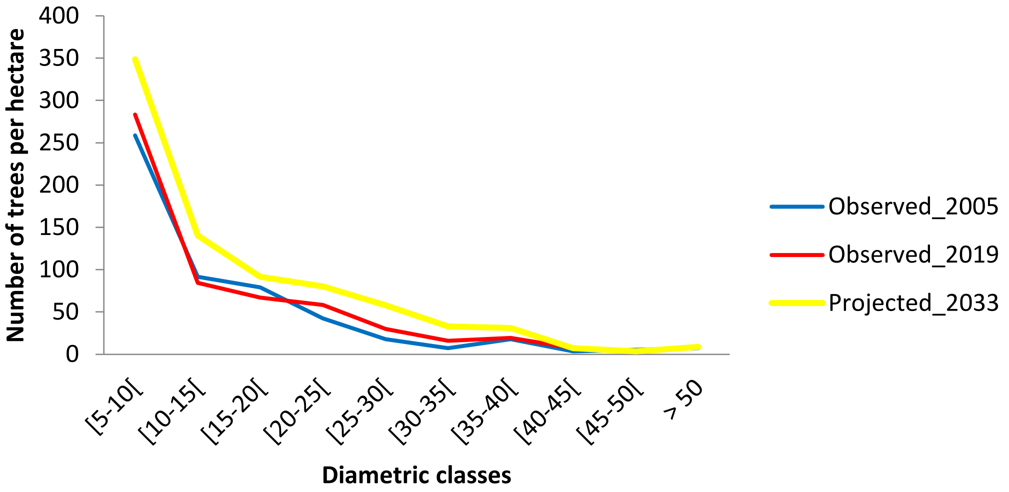
- ✓ Areas with greater fire frequency (Pearson's $r=-0.32$; $p<0.05$) and high elephant density (Pearson's $r=-0.32$, $p <0.05$) negatively influenced the vegetation dynamics in the period under study;

- ✓ The pressure of the forests in the areas close to the access roads is greater than in the interior of the forest (Pearson's $r=-0.32$; $P<0.05$);

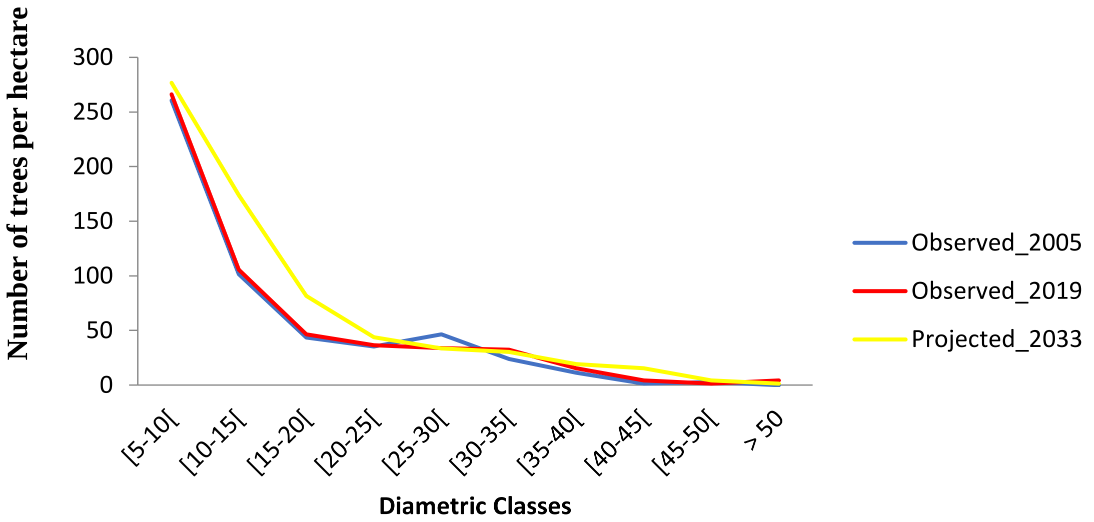
- ✓ Climate variables (annual precipitation -Pearson's $r=0.28$ and evapotranspiration; Pearson $r= 0.14$; $p<0.05$) are strong predictors of vegetation dynamics.

Prediction of the future forest structure

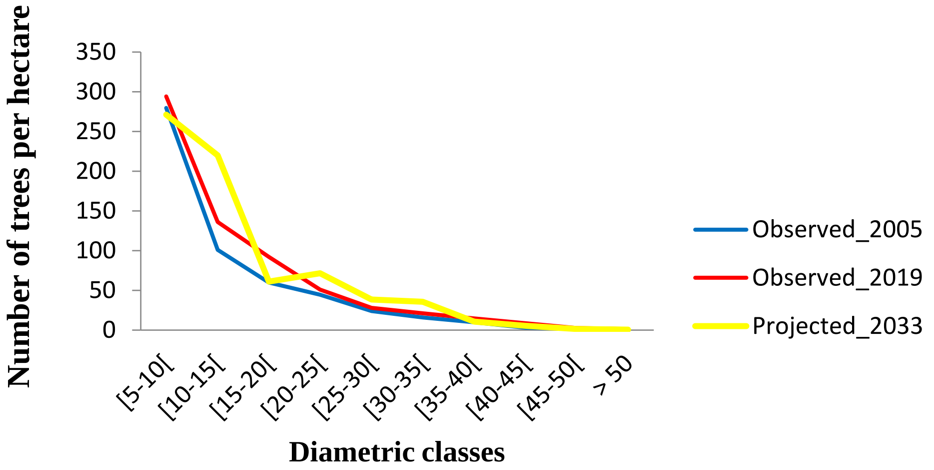
Low fire frequency (2-3)

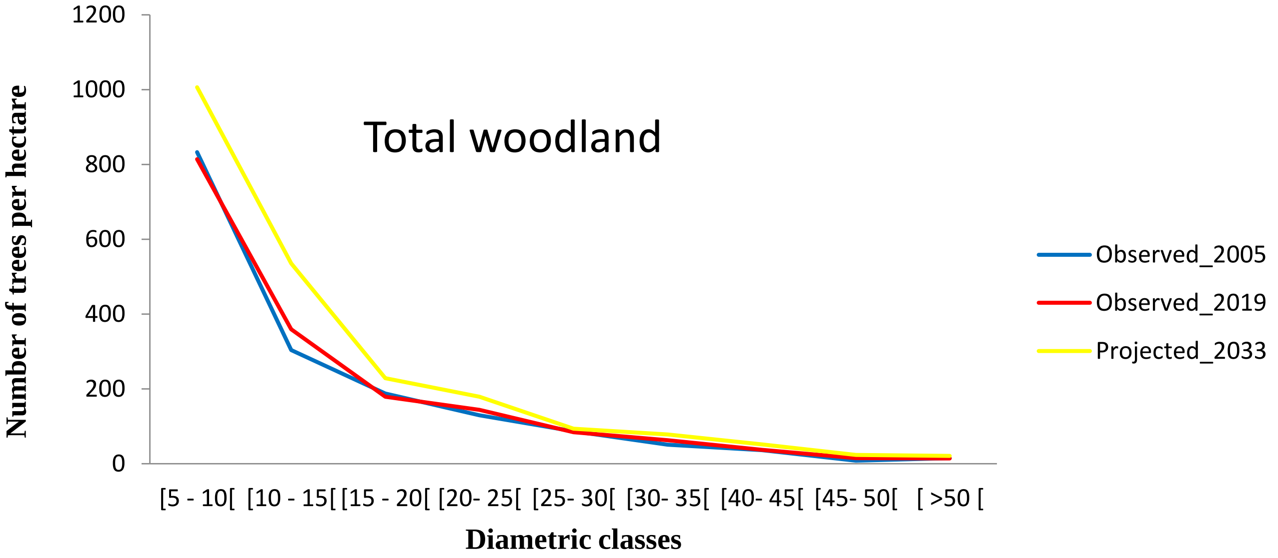


Medium fire frequency (4-6)



High fire frequency (≥7)





Fire imposes modifications

Conclusions

- The Miombo Woodland in NSR remained structurally stable during the period under analysis (2005-2019), showing positive growth and has high potential for carbon sequestration and storage (35.1 tC/ha in 2005 to 44.7 tC/ha in 2019, in low FF areas).

- However, frequent fires play an important role by reducing miombo growth, C stocks and increasing mortality.

- Miombo Carbon stocks are negatively affected by disturbance factors (fire, elephants and accessibility) and positively affected by climatic variables (precipitation and evapotranspiration).

- The projection made for the year 2033, for the entire forest, shows an increase in the density of trees per unit area over time. However, this is only observed for fire frequencies of 2-3 years or > 4 years.

Recommendations for management

- Improve the fire management program within the reserve, mainly in blocks R4 and R5, as they register frequent fires.

- Monitor the communities of the species of *Julbernardia globiflora* and *Diplorhynchus condylocarpon*, as they present high mortality caused by fires.

- Stimulate the continuity of forest monitoring, in order to continue giving subsidy to conservation programs.

Acknowledgement


Thanks