First Report

Project ID: 38140-1

Project Title: Saving the remaining population of the unique and threatened cycad species through community-based approach

Background

Encephalartos barteri ssp. barteri is the only gymnosperm known in Benin and endemic to West Africa (Benin, Nigeria, Ghana, and Togo) and member of the plants so-called cycads which are the most endangered group in the plant kingdom (Brummitt et al. 2015, Forest et al. 2018). Encephalartos barteri ssp. barteri is very slow-growing, this means that populations take a very long time to recover if adult plants are removed from wild (IUCN, 2010). Like most cycads, E. barteri ssp. barteri displays similarities to palms (Elaeis guineensis Jacq.) in its overall habit (Hill et al. 2004), so that the latter are often mistaken for the former by local people. However, the two groups of plants belong to completely different phyla and are not at all closely related (Salas-Leiva et al. 2013). The continuous collection of seeds and seedlings from the Wild is unsustainable and is depleting the populations of E. barteri ssp. Barteri in Benin. As the results, the species was reported to be vulnerable (VU) at local and global scale (Bösenberg 2010, IUCN 2010, Hunter 2010, Adomou et al. 2011).

Seven populations of E. barteri ssp. barteri were reported in Benin (Ekue et al. 2008), out of which, four populations (Gangamou, Doh, Igbomakoro and Wannou) occur in unprotected areas freely accessible by local community. The unprotected habitat for these four populations increases their risk of extinction as most of the threatened African cycad species are currently located in unprotected ecosystems (Yessoufou et al. 2016, 2017). Despite all this, no tangible conservation actions have been taken to save this species from extinction fate in Benin. Thus, we need to act fast and we feel that involving local community through increasing awareness level and developing participatory and sustainable conservation actions will be the successful conservation steps.

The continuous collection of seeds and seedlings from the Wild is unsustainable and is depleting the populations of E. Barteri. Without any conservation action, E. barteri ssp. barteri will run to extinction in the wild. Thus, to save this species from the fate of extinction, we propose to contribute to the in-situ conservation and restoration of E. barteri ssp. barteri habitats. In a first step, we will use the occurrence data acquired from botanical herbaria through previous studies on the species as well as the bioclimatic data (temperature, rainfall, and humidity) to model and predict the favourable habitats and distribution of E. barteri ssp. barteri in Benin. In a second step, the seven populations of E. barteri spp. barteri previously reported as well as the new habitats that will be found from our first objective will be surveyed. We will record the population size and abundance of E. barteri ssp. barteri to update knowledge and reassess the conservation status of E. barteri ssp. barteri in Benin. In a third step, we will collect from local communities the different uses of E. barteri ssp. barteri through an ethnobotanical survey. In addition to ethnobotanical survey, direct observed threats on this species in the field will also be taken into account in order to formulate sustainable conservation strategies. Last but not least, we are planning to involve local community and raise their awareness on the uniqueness of E. barteri ssp. barteri in Benin, the importance of its conservation. Further, in agreement with the local community, we are going to set up several groups of volunteers so called "Encephalartos ambassadors "to monitor the population of E. barteri spp. barteri in each village.

Methodology

Modelling and predicting the favourable habitats and distribution of E. barteri ssp. barteri in Benin

Study area

The analysis performed in this study covers the whole of Benin. The country is known to have three climatic zones: the Sudanian zone (9°45' to 12°25'N), the Sudano-Guinean zone (7°30' to 9°45'N) and the Guinean zone (6°25' to 7°30'N). The known populations of Encephalartos barteri ssp. barteri occur in all the climatic zones.

Species occurrence data

We searched several online biodiversity repositories to gather occurrence data on E. barteri including: iNaturalist (www.inaturalist.org), the Global Biodiversity Information Facility (GBIF, www.gbif.org) and herbaria. Once downloaded from these databases, the species occurrence data went through a cleaning process during which we only kept non-duplicated and georeferenced records from material sampling and human observation. In addition to downloaded, we explored scientific literature to collect more records on the species. Due to the scarcity in the species occurrence points, no spatial thinning was performed on the records. The cleaned dataset used to calibrate the model is shown in Figure 1.

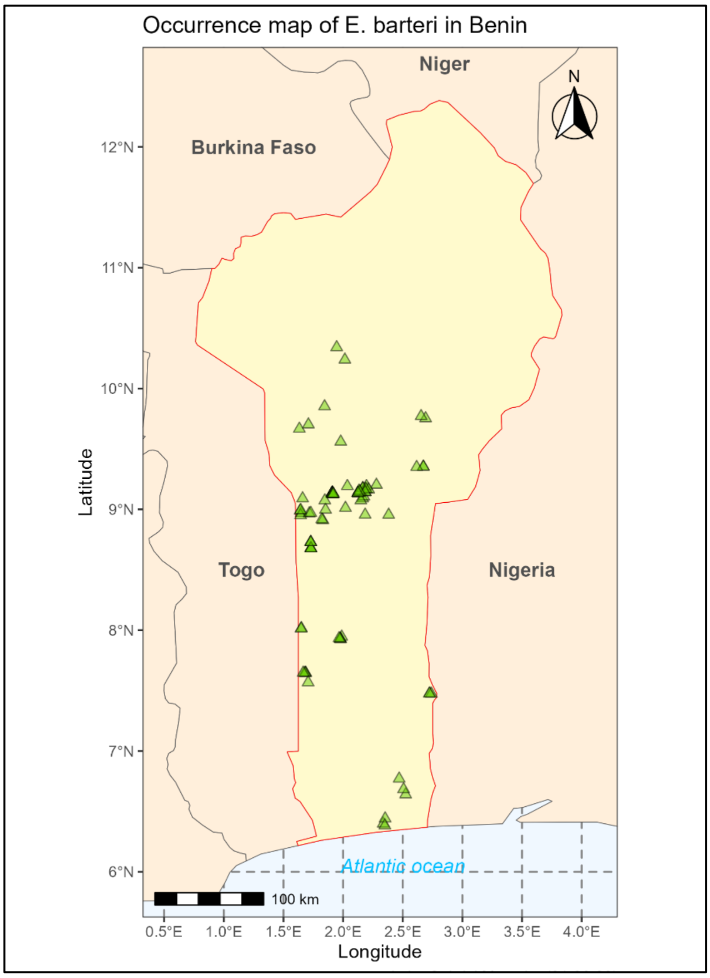

Figure 1: Occurrence data of Encephalartos barteri in Benin (generated in R packages ggplot2 (Wickham 2016) 3.4.2 and rnaturalearth 0.3.2) Reference of GBIF Occurrence Download: GBIF.org (6 October 2022) GBIF Occurrence Download https://doi.org/10.15468/dl.exmv3j.

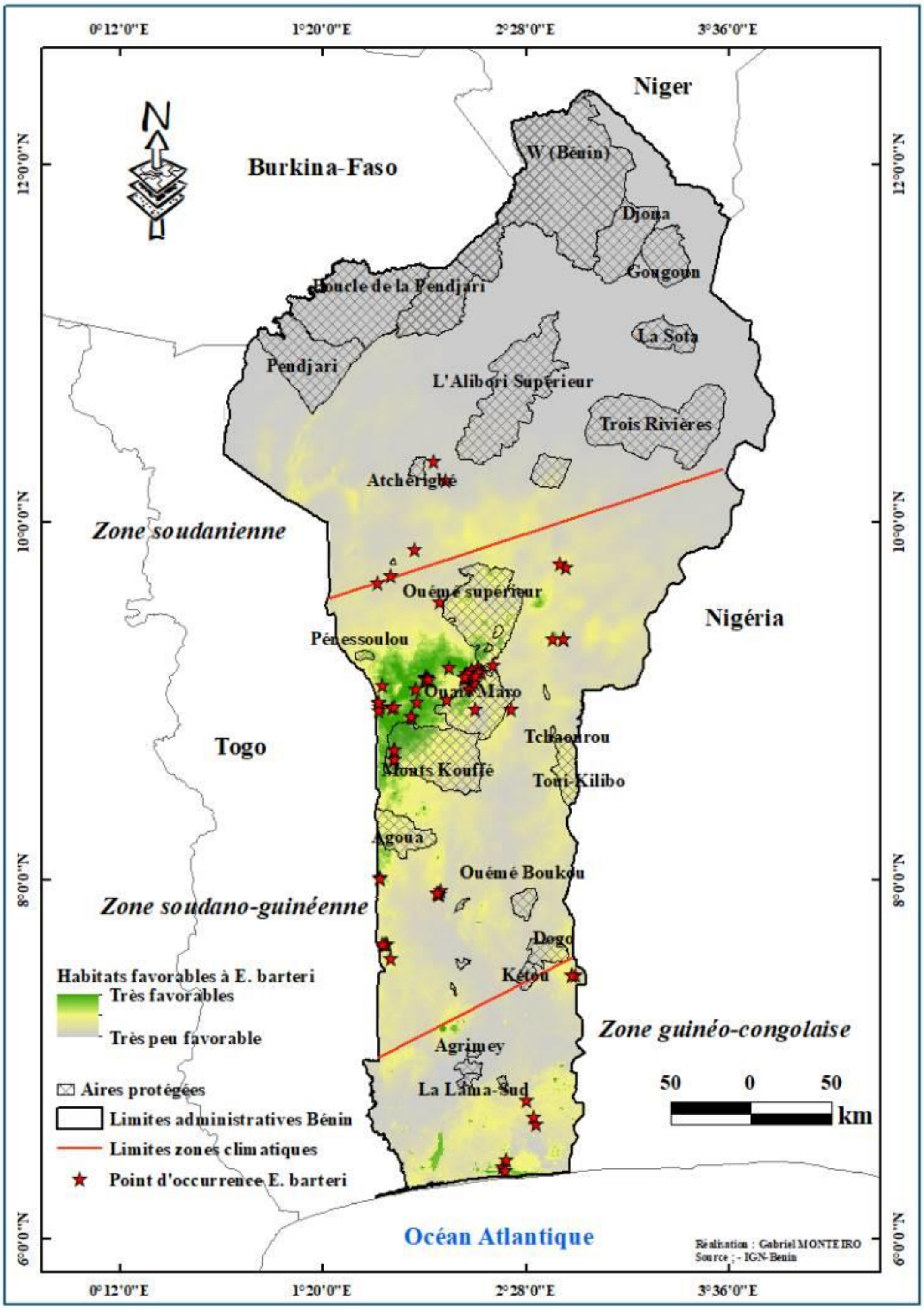

Figure 2. Favourable habitats and distribution of E. barteri ssp. barteri in Benin

Environmental predictors

We obtained 17 bioclimatic variables as estimates of present-time climate from WorldClim (Fick and Hijmans 2017) site at high resolution (30 arcsec pixels). We got similar resolution elevation data from Wordclim, as there is evidence this variable shapes species distribution and differentially influences species phenology which may have significant implications. This is particularly true for rare plant species in sensitive mountain ecosystems ((Adedoja, Kehinde, and Samways 2020; Lannuzel et al. 2021). Plus, we downloaded soil Cation Exchange Capacity at pH 7 (CEC) and 5 cm depth from SoilGrids (soilgrids. org - downloaded in December 2022), which provides the data at 250 m resolution (Poggio et al. 2021). We chose to include CEC in this analysis because it is a chemical soil property, easily available as high-resolution GIS layer and often used to perform ecological studies in tropical areas (Figueiredo et al. 2018; Zuquim et al. 2020; Levis et al. 2017). Cation exchange capacity (CEC) is a measure of a soil's ability to hold positively charged ions. It is a property of the soil that is related to the clay content and other soil properties. CEC plays a role in several important soil processes, including heavy metal removal, nutrient uptake, and species distribution (Shahrokhi-Shahraki et al. 2021; Rodrigues et al. 2019; Martel, De Kimpe, and Laverdière 1978). In addition, we used Organic Carbon Stock (OCS) from SoilGrids as an indicator of physio-chemical and biological properties of soils in the study areas. This data was downloaded at at 250 m resolution. Actually, the total organic carbon content in soil serves as a dynamic indicator of soil physical quality, allowing for the monitoring of both temporal and spatial variations in soil quality (Singh, Khera, and Santra 2012).

All predictors were prepared as ASCII files and adequately resampled at 1x1 km resolution with the R package raster 3.6.20 (Hijmans 2023). Collinearity issue among environmental variables can introduce bias in parameter estimation by inflating the variance of regression parameters, and can lead to inaccurate choices when selecting relevant predictors for models(Mela and Kopalle 2002; Ruffell, Banks-Leite, and Didham 2016). To handle this concern, we extracted predictor values at occurrence points and applied the variance inflation factor (VIF) function from the SDM package (Naimi and Araújo 2016). This allowed us to retain the variables with lower correlation in our models. Additionally, through preliminary model runs, we identified the most influential variables among those with lower correlation.

Model calibration and evaluation

We carried all the process of model fitting and calibration in R software version 3.4.0 (R Core Team 2023). We used the SDM package for all analysis in R as it offers flexibility in adjusting the predictive performances models. To fit the predictive models of suitable habitats to E. barteri we chose algorithms MaxEnt (Phillips, Anderson, and Schapire 2006) as we only have the presence data of the species. MaxEnt is one of the top performing machine learning algorithms. It is a good choice for this analysis because it is designed to model presence-background data. It is not a stochastic model (meaning that the results are consistent each time the model is run), and it is computationally efficient (Valavi et al. 2022). We fitted models to 10000 background points, with each sampling-then-modelling repeated 25 times to account for the variability in the selected background samples. Replications were performed using three sampling techniques: cross validation, subsampling and bootstrapping. To assess the predictive performance, we measured the discrimination ability and reliability of the models based one several statistics: the area under the curve (AUC) of the receiver-operating characteristics plot (Yackulic et al. 2013), the true skill statistics (TSS)(Allouche, Tsoar, and Kadmon 2006).

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