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Biodiversity and carbon stocks in different land use types in the Sudanian Zone of Burkina Faso, West Africa

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ABSTRACT

Lack of data on carbon stocks hampers implementation of emission reduction mechanisms (e.g., REDD+). Addressing this issue is relevant, especially when combined with other challenges such as preserving biodiversity. The present study assessed tree diversity (Shannon–Wiener's index) and carbon stocks of different land uses in Balé and Ziro sites in Sudanian zone of Burkina Faso. Aboveground carbon stock was evaluated using generalized equation. Belowground carbon was assessed by excavating plant parts in samples of soil in each plot. Regarding soil sampling for C-content assessment, four locations were selected in each plot and soil was sampled at the depths of 0–20 cm and 20–50 cm, using an auger. The four soil samples from each depth were pooled, thoroughly mixed and a composite soil sample taken to the laboratory for carbon content measurement using the Black and Walkley method. The C-content was then used for calculating SOC. In Balé and Ziro, 85 and 106 species, 63 and 82 genera, 29 and 35 families were identified, respectively, with the Leguminosae family as most dominant. Natural vegetation stands (NV) and fallows showed high richness and diversity compared to parklands. Soil was found the most important carbon pool. Highest values of aboveground, belowground and soil C-stocks in Ziro (13.9, 14.71 and 67.1 Mg/ha) were recorded in community managed forests (CMF) logged 12 years ago, while equivalent values for Balé (25.76, 14.96 and 53.02 Mg/ha) were recorded in the dense NV. However, irrespective of C pool, the difference between CMFs and the 100 trees/ha *Vitellaria* parkland was not significant. Correlations were found between species richness and above and belowground C-stocks ($R^2 = 0.22$, $p < 0.0001$; $R^2 = 0.33$, $p < 0.0001$). Overall, dense *Vitellaria* parklands, apart from allowing tree-crop integration, have real potentials for C sequestration. Also, C-sequestration and biodiversity conservation are likely not conflicting targets.

1. Introduction

Climate change is a worldwide concern that is driven by increased atmospheric concentrations of greenhouse gases of which, carbon dioxide (CO_2) is the most important (Stavi and Lal, 2013). Land management practices that reduce emission of CO_2 or sequester carbon are being considered in climate change mitigation strategies (Zomer et al., 2008). Among the efforts to sustain emissions reductions, programs like the Clean Development Mechanism (CDM) initiated under the Kyoto protocol and REDD + under the UNFCCC are making financial resources available to enhance carbon sequestration and reduce emissions from land use change. Through these mechanisms, carbon finance offers new opportunities to improve the sustainability of tropical landscapes and generate social benefits like poverty reduction and livelihood security (Mendis and Openshaw, 2004; Ogle et al., 2014). Implementation of these mechanisms is constrained by the availability of data on carbon stocks and emissions associated with different land uses and land use change in tropical countries (Wertz-Kanounnikoff et al., 2008; Verchot et al., 2012).

Over the last decades, the conservation of biodiversity has become an objective of international conventions, national governments, state agencies, nongovernmental organizations, local communities, school clubs, and individuals (Redford and Richter, 1999). Indeed, changes in components of biodiversity

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cause concern for ethical and aesthetic reasons, but they also have a strong potential to alter ecosystem properties and the goods and services they provide to humanity (Hooper et al., 2005). In the context of Burkina Faso with dry forest ecosystems, biodiversity needs to be promoted to improve regulation services at the landscape level (soil fertility, water infiltration, etc.) and also because, the goods and services provided by the ecosystems is important for local people's livelihoods, their food security and their adaptation to climate changes. Biodiversity is under the influence of many biotic and abiotic factors which are themselves under the influence of human activities/practices. In the current context of climate changes, these practices are changing to allow increased resilience and adaptation to new environmental conditions and to seek ways for mitigation. Moreover, it is believed that climate change, deforestation, forest degradation, and biodiversity are interlinked to each other (Mandal et al., 2013) and for some ecosystems, biodiversity was shown to often promote stability and primary productivity, and therefore carbon stocks (Hicks et al., 2014). However, no clear global relationship between biodiversity and carbon sequestration is apparent; and it is also not understood how local and landscape level changes in biodiversity might alter carbon cycling. All this limit more mature policy development for their co-management (Midgley et al., 2010).

In the Sudanian zone of West Africa in general and in Burkina Faso particularly, different land uses and management systems are encountered ranging from State forests (managed by central administration) to Community managed forests and to Natural vegetation not under defined management per se (known as protected forest "forêts protégées") (Sawadogo, 2006). Plantation forests, initiated some decades ago (1970s) using exotic species such as *Eucalyptus camaldulensis* Denh., *Gmelina arborea* Roxb., and *Tectona grandis* L.f., although not widely spread today, are still encountered, but the new trend is towards tree crop species like cashew and mango (*Anacardium occidentale*, *Mangifera indica*). Other common tree-related land use types in the country are parklands, which are agroforestry areas, similar to natural savannah where mature trees of a range of species (*Vitellaria paradoxa*, *Parkia biglobosa*, *Adansonia digitata*, *Faidherbia albida*) are preserved and among which annual crops are planted (Bayala et al., 2014). In the past parklands were used in a rotational spatial dynamic, shifting from agriculture land to fallows and vice versa. Recently, the practice of fallows, whether in Burkina Faso or elsewhere in sub-Saharan Africa, which allowed the restoration of soil, has received little attention from farmers due to the increasing population pressure on arable land (Kumar and Nair, 2011). Tree-related land use practices, namely agriculture/agroforestry and forestry, can contribute to mitigating increasing atmospheric CO_2 concentrations because of their high capacities for capturing and storing atmospheric CO_2 in vegetation, soils, and biomass products (Kumar and Nair, 2011; Jose and Bardhan, 2012). They could, therefore, contribute to consolidate the global development of carbon markets and associated trading options such as Payment for Environmental Services in forests. Particularly, since the adoption of the Marrakech Accords in 2001 under the Kyoto Protocol, agroforestry has gained increased attention as a strategy to sequester carbon (C) and mitigate global climate change (Albrecht and Kandji, 2003). However, although the system is spread over one billion ha in diverse ecoregions around the world (Kumar and Nair, 2011), our understanding of C sequestration in specific agroforestry practices from around the world is rudimentary at best (Jose and Bardhan, 2012).

We hypothesized that (i) some land use types in this Sudanian ecosystems would have far better carbon sequestration potentials and be potential candidates for mitigation perspective; (ii) land use types with high carbon sequestration potential would not show biodiversity preserving ability (which is also a pressing regional challenges; see Batjes (2001)) in the sense that only few species would be contributing to the majority of biomass. Therefore the

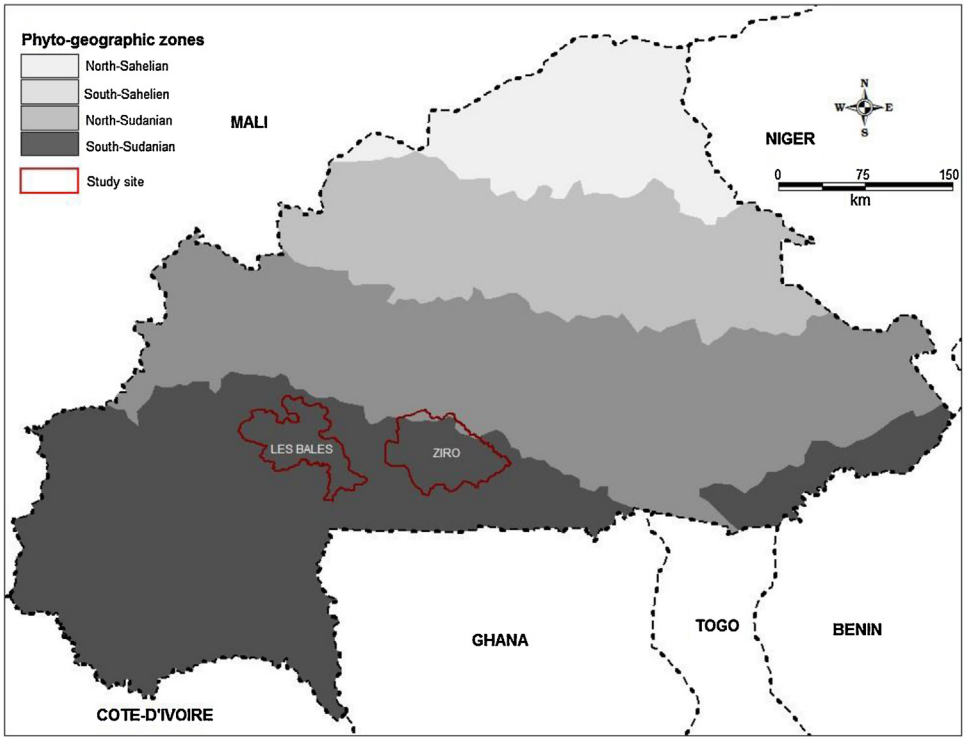

Fig. 1. Vegetation map of Burkina Faso and location of the two study sites.
(Adapted by CTIG/INERA/Burkina Faso November, 2013, after Fontès and Guinko, 1995).