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People, parks and rangelands: an analysis of three-dimensional woody vegetation structure in a semi-arid savanna

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Abstract

Effective management of protected areas and communal rangelands, which are often juxtaposed in developing countries, is essential to prevent biodiversity decline and ensure a sustainable resource base for rural communities. However, in human-modified landscapes, there are complex interactions between factors that determine woody vegetation structural patterns. While the underlying biophysical template continues to influence vegetation patterns in a predictable manner; the intensity and type of disturbances that are the result of resource extraction, fire and herbivory can have an overriding impact. In order to effectively conserve biodiversity and plan for sustainable resource use, an understanding of land-use and land management is required. A case study of adjacent protected areas (Kruger National Park (KNP), a national protected area and Sabi Sand Wildtuin (SSW), a private game reserve) and communal rangelands (in Bushbuckridge Municipality (BBR) with varying intensities of use) in north-eastern South African savannas was used to study the spatio-temporal patterns of three-dimensional (3D) woody vegetation structure as a result of natural resource management and abiotic drivers.

The aim of this PhD thesis is to advance our understanding of the effects of management of natural resources on spatio-temporal patterns of 3D woody vegetation structure across land uses in a heterogeneous semi-arid savanna system. Vegetation structure was measured using small-footprint, discrete-return LiDAR (Light Detection and Ranging) collected by the CAO (Carnegie Airborne Observatory) Alpha System over 35 000 ha across the study area. 3D woody vegetation structure was compared both within land uses (KNP versus northern SSW, and within BBR) and between land-uses (southern SSW versus BBR) to address two objectives, namely 1. Can LiDAR be used as a monitoring tool for management of woody vegetation structure and biodiversity in semi-arid savannas and 2. What is the impact of land use and the corresponding management of resources on woody vegetation structure in semi-arid savannas?

Different land-use legacy timelines and current management objectives at sites in KNP and northern SSW has resulted in an average of 2.5 times higher vegetation density <3 m and >6 m in SSW. These differences in vegetation structure are exacerbated by current management practices, with implications for faunal biodiversity conservation across all

scales. Not all reserves are equal in their ability to conserve biodiversity and such knowledge should be considered in conservation planning and management. In the communal rangelands, intense fuelwood harvesting has resulted in coppiced trees <3 m in height, and the only trees >5 m are preserved for cultural reasons, producing similar vegetation patterns to Sabi Sand Wildtuin. Disturbance (extraction and grazing) gradients occur with distance from settlements, with utilization intensity affecting vegetation cover within the size class distributions, but not the shape. Gradients diminish under heavier utilization resulting in a more structurally homogenous landscape, which may be used as an early warning sign of woodland degradation. The increase in >3 m tall trees was twice as high in low intensity use CRs adjacent to SSW compared to those in southern SSW from 2008 to 2010, indicating the impacts of treefall from megaherbivores and fire management reducing plant recruitment/regeneration in the protected area. Knowledge from investigation of socio-ecological drivers in the two land-uses were used to construct an ecologically relevant 3D woody vegetation structural classification which can be used by land managers to plan for sustainable resource use and effective conservation of biodiversity.

The management of natural resources, including direct use of fuelwood and the management of herbivory and fire affects woody structural dynamics; however, a lack of knowledge exists around the social and ecological context of natural resource management. The use of remote sensing, the knowledge of savanna ecology and an understanding of community-based natural resource management is integrated in this thesis to contribute to the context specific understanding of drivers of woody vegetation structure in two socio-ecological systems (protected areas and communal rangelands) which can be used in sustainable natural resource management plans.