Chapter 5.2

Structural biodiversity monitoring in savanna ecosystems: Integrating LiDAR and high resolution imagery through object-based image analysis

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ABSTRACT: Savannas are heterogeneous systems characterized by the coexistence of grasses and woody trees. Growing recognition of the importance of the structural component of biodiversity has highlighted the need to understand the spatial distribution and temporal dynamics of woody plant structural diversity. Advances in LiDAR technology have enabled three dimensional information of vegetation to be obtained remotely over large areas. Whilst the use of LiDAR has gained considerable momentum in forested areas there has been limited application to savanna systems. We explore the applicability of LiDAR and object-based image analysis to the monitoring of woody structural diversity in a savanna system. We demonstrate how an object-based approach to image analysis significantly improves the accuracy of woody layer classification form in a heterogeneous landscape. Furthermore we illustrate how standard approaches to LiDAR derived canopy models suffer from interpolation artifacts in savannas, due to the heterogeneity of the woody layer. By integrating LiDAR with high resolution aerial photography, through object-based analysis, these artifacts can be removed to produce a robust canopy model. The object-based integration of LiDAR with aerial imagery holds immense potential for structural diversity monitoring in savannas.
1 Monitoring structural biodiversity in savanna ecosystems

Savannas are heterogeneous environments driven by a wide range of factors at multiple scales. A key characteristic of savanna landscapes is the co-dominance of two life forms – grasses and woody trees (Scholes and Walker 1993). The spatial structure and composition of savannas is controlled primarily at the broad scale by climate and geology, whilst rainfall, topography, soil type, fire and herbivory influence structure at a range of finer scales (Pickett et al. 2003, Gillson 2004a, Sankaran et al. 2005). In addition to being spatially heterogeneous, savannas are highly dynamic over time (Gillson 2004b). The variability of these systems presents challenges to their management and conservation.

Management of savanna systems has historically taken place under a balance of nature/homogeneity paradigm (Rogers 2003). The growing recognition of savanna heterogeneity has led to changes in the management of certain savanna systems. In the Kruger Park (South Africa), for example, management has adopted a heterogeneity paradigm that ‘aims to maintain biodiversity in all its facets and fluxes’ (Braack 1997). This paradigm shift reflects a holistic view of biodiversity which incorporates the composition, structure and function of ecological systems at multiple scales (Noss 1990). Given that heterogeneity is considered to be the ultimate source of biodiversity (Pickett et al. 2003), monitoring system heterogeneity should be of high management priority within savanna systems.

1.1 Monitoring savanna heterogeneity remotely

Monitoring of savanna vegetation has traditionally taken place through aerial photographic analyses and field surveys. Ground based field monitoring can provide detailed information of changes in vegetation structure over time, but is very time intensive and can only feasibly be conducted over small spatial scales. Fixed point photography can reveal changes in the three-dimensional structure of vegetation, but it suffers the same constraints as field measurements. Extrapolating results obtained at small spatial scales to larger scales is difficult in heterogeneous systems like savannas. Managers need to be able to monitor large spatial areas to encompass system variability. Remote sensing techniques at broader scales therefore need to be employed.

Savannas have historically presented numerous challenges to the field of remote sensing. Given their proximity to the tropics, and the regular occurrence of thunderstorms in summer months, cloud free days are rarely