FIRE AS BROWSER:
USING LIDAR TO VISUALISE AND QUANTIFY WOODY STRUCTURE ON A LONG-TERM FIRE EXPERIMENT IN AN AFRICAN SAVANNA

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BACKGROUND

Although many ecologists subscribe to a definition that recognises composition, structure and function as part of biodiversity, a quick overview of literature suggests a bias in biodiversity studies towards only one of these components, namely composition. This is partly due to entrenched paradigms of biodiversity centering around species diversity and protection, but also due to the complexity of defining, and difficulty in quantifying, structure and function. However, new advances in active remote sensing technology (including light detection and ranging; LiDAR) are providing tools with which the 3-dimensional structure of vegetation can be studied at high resolution and over large scales in order to explore the complexity of processes driving patterns of vegetation structure.

OBJECTIVE

The main aim of this study was to use LiDAR data to visualize, quantify and understand how fire frequency and fire season act and interact to affect vertical woody vegetation structure across a rainfall gradient in a savanna system.

STUDY SITE

Fire research began in the Kruger National Park (KNP), South Africa, in 1954 with the establishment of one of few long-term fire ecology research experiments in Africa. The aim of the Experiment Burn Plots (EBPs) was to study the effects of fire (frequency and season) on the vegetation of the KNP under the grazing pressure of indigenous herbivores. The experiment consisted of the application of fires at varying return intervals and seasons, and protection from fire, on a series of approximately7 ha plots in four of the major vege tation landscapes of the KNP. Each treatment was replicated four times in each landscape. The treatments included annual winter fires in August and biennial and triennial fires in August, October, December, February and April, and have consistently been applied over the past 54 years.

METHODS

High resolution, discrete return airborne LiDAR data were collected over the EBPs, using the state-of-the-art Carnegie Airborne Observatory system. After pre-processing, the LiDAR data were used to generate a canopy height model for each of the EBPs (at a 1.12m x 1.12m spatial resolution).

ANALYSIS

Using the LiDAR derived surfaces described above, the absolute and relative difference in density of woody canopy cover was calculated between the various fire treatment plots and the associated fire exclusion plots. This was calculated for each incremental 0.5m height class. These differences can be seen as the “consumption” of woody vegetation at different height classes due to long-term “browsing” by fire.

RESULTS

LiDAR imagery was very effective for visualising and quantifying the vertical structure of woody vegetation and for comparing the effects of various fire regimes. The results show how woody vegetation structure was altered at different height classes due to differences in fire frequency, fire season and the geological template and rainfall gradient.

MANAGEMENT IMPLICATIONS

Since fires can be artificially induced or suppressed, it is important that land managers understand how different fire regimes alter woody vegetation structure. Depending on the desired state of an area (e.g. a productive agricultural land versus a functional and resilient conservation area), the results from this study can be used to understand how fire regimes can be used to achieve landscapes with different vegetation structure. Considering that KNP management aims to conserve a resilient and functional system, this study suggests that a heterogeneous mixture of fire regimes should be applied in space and time in order to create a mosaic of woody vegetation structure that evolves and moves around the landscape. Fixed fire regimes would be unnatural and give rise to a directional trend in woody vegetation structure.

CONCLUSIONS

This is the first study to explore LiDAR derived structural profiles for one of the best known and most intensively studied long-term fire experiments in Africa. To our knowledge, this is the first study of its kind where LiDAR imagery has been used to better understand fire as a major driver of woody vegetation patterns in African savannas. Previous studies exploring how fire influenced vertical vegetation structure had to rely on crude vegetation height measurements collected along transects. However, with LiDAR it was possible to spatially-explicity analyse high resolution structural information that was collected wall-to-wall across the experimental plots. Using the LiDAR data both visually and quantitatively, this study solidifies but also challenges some of the existing theories regarding the effects of fires onwoody vegetation structure in savannas. We belief this study provides a good example of how LiDAR technology can contribute towards understanding one of the key processes in savannas better and consequently informing land managers on how to apply fires in order to achieve their desired outcomes.