EcoRestore: Decision Support System to restore the productivity of degraded rangelands in southern Africa

Kellner, K.*, Pretorius, D.$ and Marais, C.°

* School of Biological Sciences and Unit for Environmental Sciences and Management (UESM), North-West University, Potchefstroom, South Africa
E-mail: Klaus.Kellner@nwu.ac.za

$ Professional GISc practitioner, SMC Synergy, Pretoria, South Africa
E-mail: dirk@smc-synergy.co.za

° Chief Director, Natural Resource Management Programme, Department of Environment, Forestry and Fisheries, Cape Town, South Africa
E-mail: CMarais@environment@gov.za

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Abstract

Land degradation is a multifaceted problem that affects the agricultural productivity of land due to a loss of vegetation cover and can often be ascribed to bush encroachment in savanna and grassland rangelands. Bush encroachment entails the increase in abundance and density of indigenous and alien woody vegetation (i.e. shrub thickening), which has a negative impact on the tree-grass ratio, biodiversity, as well as on a range of ecosystem services that affect the well-being of land users, often causing an increase in poverty and the introduction of non-sustainable land management practices, especially in arid- and semi-arid regions mostly affected by climate change. In response, the North-West University, in collaboration with the Natural Resource Management (NRM) programme of the South African Department of Environment, Forestry and Fisheries (DEFF) and consultants, developed the Bush Expert Information Management System (BEIMS) that will help land users to make scientifically sound decisions regarding the restoration/rehabilitation and sustainable management of degraded land. The core components of the BEIMS are the EcoRestore Decision Support System (DSS) that contains guidelines for restoration after bush control and the Bushmon database that contains information (including spatial location) of bush encroachment restoration research projects. The BEIMS (abbreviated as Bush Expert) is a cloud-based, easily accessible online system which can also be linked to a standalone Global Information System via a spatial database link. Stemming from the BEIMS, the EcoRestore DSS can provide scientifically assessed information on projects where restoration technologies have been applied – including aerial photography that track the before and after successes of restoration/rehabilitation processes. To follow is a discussion of the results of a number of restoration applications derived with the aid of BEIMS, with due consideration for the current functionality and accessibility of the system.

Introduction

Land degradation (LD) is a worldwide phenomenon in drylands, negatively impacting agricultural productivity and ecosystem services and the livelihoods of many people, especially those living from the land (MEA 2005; Hoffman and Ashwell 2001). A multitude of factors have been identified as the drivers of LD in rangelands (Kgosikoma and Mogotsi 2013; O'Connor et al. 2014), which include climate change, certain land-use practices in different land tenure regimes, over-grazing, the invasion of alien plants, loss of top soil through erosion (wind and water) and the loss of biodiversity (Von Maltitz and Evans 1998; Ward 2005). Land degradation leads to an increase in woody density (shrubs and trees), causing an imbalance in the tree-grass ratio which leads to *bush thickening* (BT) (increase in density of woody species already occurring in the region) and/or *bush encroachment* (BE) (increase in density and invasion of woody species not occurring in the region) (De Klerk 2004). Due to competition for soil moisture, vegetation cover – especially that of grasses decreases, ultimately reducing fodder production for grazing animals in savanna rangelands (Von Maltitz et al. 2019). Bush

encroachment/thickening is regarded as one of the most extensive forms of LD in arid and semi-arid rangelands, causing biome shifts from open savannas to closed woodlands and altering the functions and biodiversity of the original savanna by reducing the economic benefits of the rangelands (O'Connor et al. 2014; Eldridge et al. 2011).

Recent studies conducted by Turpie et al. (2019) and Warren et al. (2018) found that BE affects around 7.3 million ha of the land area in South Africa, especially in grassland and savanna biomes which, respectively, comprise around 27.9% and 32.5% of the land surface area.

A number of technologies have been implemented by land users as well as private and government organisations to control the increase in woody density and increase vegetation cover of palatable, climax grass species in attempts to improve fodder production and grazing capacity (Harmse 2013; Harmse et al. 2016; Kellner et al. 2021; Joubert et al. 2014; Lukomska et al. 2014; Smit 2004).

In response to these studies, Turpie et al. (2019) recommended that an information and advisory service be established to, amongst others, offer guidelines for the management and that, secondly, further research should be conducted to determine the biodiversity impacts of BE, the potential effects of woody biomass removal on soil fertility and the possible role of woody cover in restoring degraded soils.

Subsequently, the North-West University (NWU), in collaboration with the Natural Resource Management (NRM) programme of the Department of Environment, Forestry and Fisheries (DEFF) as well as several consultants, developed the Bush Expert Decision Support System (DSS). Also resorting under this system is the EcoRestore Expert System that contains information on restoration after bush control.

The EcoRestore DSS maintains a database that includes case studies of technologies and approaches that have been researched and applied by rangeland managers, scientists and farmers over the short and long term in an attempt to restore/rehabilitate degraded rangelands or to combat the problem of BE and alien species invasion (Barac 2003; Barac et al. 2004). Primarily, the intention with the DSS is to optimise the exchange of knowledge concerning practices to restore/rehabilitate degraded rangelands that have been applied previously and to disseminate this to as many users as possible for future rangeland management applications. Currently, the case studies in the DSS mainly cover technologies captured in studies conducted in Namibia (Barac 2003). It is, however, envisaged that case studies from other Southern African Development Community countries, including South Africa, will be included within the near future.

Development of the EcoRestore DSS

Initially, EcoRestore DSS was developed as an online application in 2003, at which time it was also made available as a CD-ROM (Barac 2003). The online version was hosted by the NWU and did not include a spatial database platform. Currently, an improved version of EcoRestore DSS as a component of the Bush Expert Information and Management System (BEIMS) is being re-engineered in three phases (Figure 1). Even though BEIMS is still in a developmental stage, it can be accessed via two websites, i.e. www.beims.co.za and www.bushmon.co.za. Note, though, that to access all BEIMS functions (databases, maps, etc.), registration and a password will be required.

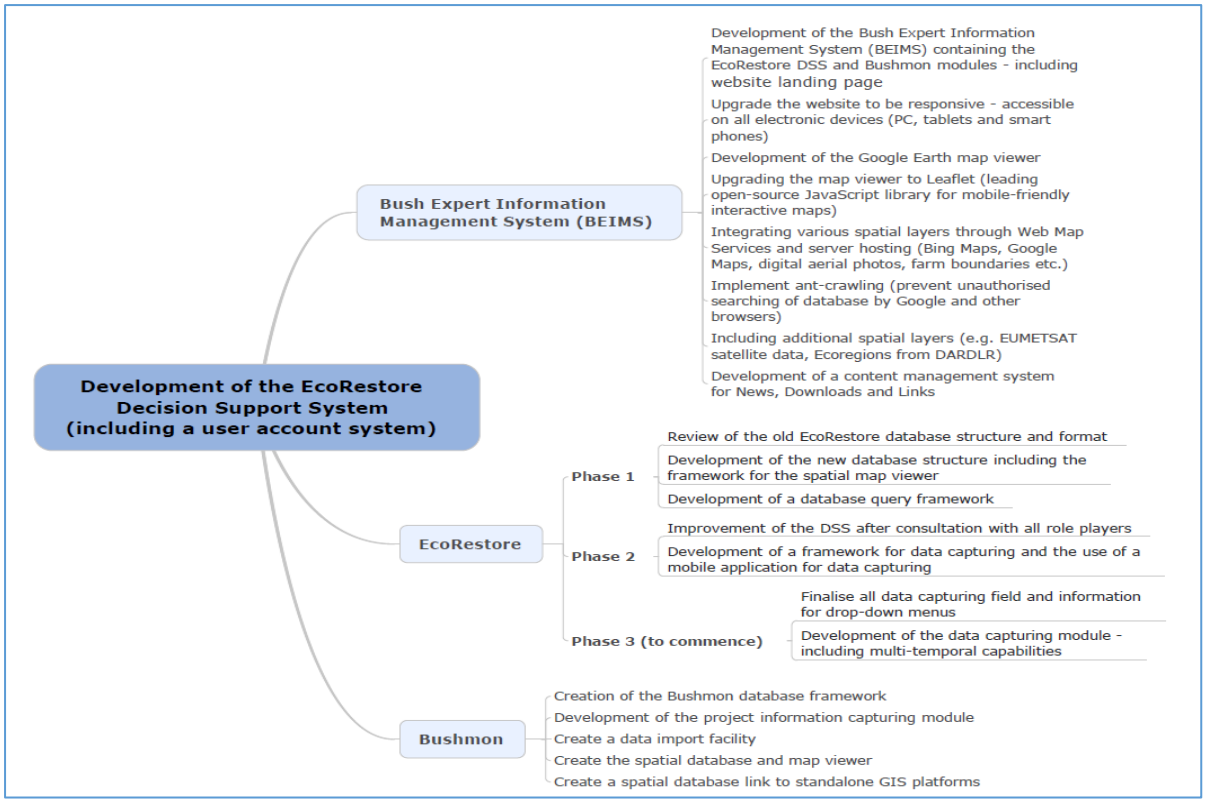

Figure 1. Steps in the development of the Bush Expert Information Management system (BEIMS), with the inclusion of EcoRestore DSS and Bushmon modules.

The map viewer interface of BEIMS was developed in Leaflet, an open-source JavaScript library for interactive web maps. It is lightweight, simple and flexible, and is probably the most popular open-source mapping library at the moment.

The use of the Leaflet map viewer allows the integration of various base map sources (e.g. Bing and Google maps), user-created spatial data (e.g. EcoRestore and Bushmon case studies and projects) as well as links to Web Map Service data sources (e.g. ESRI farm portions and digital aerial photographs).

As mentioned, the development of Phase 3 will commence shortly and will focus on the finalisation of all data capturing fields and information for drop-down menus. All modules - including multi-temporal capabilities – will be available on the internet and as mobile application (app).

The Bush Expert DSS and BEIMS can be used to identify the best technologies to restore the ecosystem functions and services of degraded land, especially after attempts have been made to control bush encroachment. BEIMS will help land users, land managers and policy makers to make scientifically sound decisions regarding the restoration/rehabilitation and sustainable land management (Mangani et al. 2020; Sebitloane et al. 2020).

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