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HOW TO CITE:
Siebert F, Bombo AB, Archibald S, Greve M, Fidelis A. Introducing bud bank and below-ground plant organ research to South Africa: Report on a workshop and the way forward. S Afr J Sci. 2019;115(11/12), Art. #6803, 2 pages. https://doi.org/10.17159/sajs.2019/6803

ARTICLE INCLUDES:
☐ Peer review
☐ Supplementary material

KEYWORDS:
regeneration, grasslands, savannas, ecosystem conservation, ecosystem management

PUBLISHED:
27 November 2019

Introducing bud bank and below-ground plant organ research to South Africa: Report on a workshop and the way forward

Bud banks are the source of vegetative reproduction of plants. They are linked to regeneration strategies of plant communities in ecosystems prone to disturbances.[1] Bud bank research is fast moving up the research agenda as an approach to better understand the dynamics and resilience of ecosystems.[2] Regeneration from seed is only one of a myriad of strategies that plants use to survive and flourish in ecosystems with seasonal rainfall, above-ground consumers such as fire and herbivores, or recurrent droughts. Because the vegetation dynamics, structure and function of southern African grassy biomes are driven by these disturbances, one would expect interesting below-ground regeneration strategies. However, studies on below-ground traits are underrepresented in the scientific literature, with only a few contributions pertaining to 'below-ground bud bank' as the main topic. Furthermore, most of these studies have been conducted in the northern hemisphere, such as in China, central Europe and the USA.[3] Bud bank related research in the southern hemisphere is represented by one study from South American grasslands[4] and one from savannas in Botswana[3]. Recent papers on 'underground trees of Africa'[5] and the underground storage organs characteristic of 'old-growth grasslands'[6] have highlighted the importance of quantifying and describing below-ground regeneration strategies to understand the evolution of our ecosystems, and appropriate ways to manage and conserve them. The savanna and grassland biomes in southern Africa host a high richness of herbaceous plants, particularly forbs, which are often more abundant below ground than in the standing vegetation.[7] Below-ground bud banks comprise an important regeneration strategy for many savanna species, and yet very little is known about below-ground strategies for plant growth-form coexistence in grassy ecosystems.

Considering the importance of understanding the 'below-ground world' for a broader comprehension of savanna ecosystem resilience in general, savanna ecologists from southern Africa and Brazil discussed the need to bring local researchers up to date with the latest approaches in regeneration strategies. In May 2019, a first hands-on workshop on how to survey bud banks and below-ground plant organs in grassy ecosystems was hosted by the Forb Ecology Research Group from the Unit for Environmental Sciences and Management, North-West University (Potchefstroom, South Africa), in collaboration with São Paulo State University (UNESP) in Brazil. This 2-day event attracted several established researchers in southern Africa and a robust community of young scientists and postgraduate students representing North-West University, University of Pretoria, University of the Witwatersrand and University of Edinburgh (Scotland). Considering the novelty of the subject and the underrepresentation of similar studies on grassy biomes in southern Africa, the workshop aimed to bring this approach to the ecological research community, broadening the understanding of the dynamics of southern African grassy biomes for improved management and conservation of these highly diverse ecosystems.

The 2-day workshop covered relevant background information on bud bank related ecological research, after which delegates had the opportunity to undertake field surveying at the Unit for Environmental Sciences and Management research facility outside Potchefstroom, followed by working group sessions to analyse and interpret results. The theoretical background of the workshop highlighted the critical role of the below-ground structures in regeneration after disturbances, and the importance of a standardised approach to investigate the morphology and terminology of below-ground bud-bearing organs. Based on the available literature on the morphology and terminology of below-ground bud organs[1,2], the workshop emphasised the importance of these less explored functional traits for future studies in grassland and savanna ecology. The event furthermore provided opportunities among scientists interested in grassy ecosystems to network and discuss projects and questions related to grassland and savanna dynamics and conservation. Young scientists had the opportunity to partake in such discussions to stimulate their thinking on the links between diversity, function, evolutionary history and disturbance in grassy biomes of South Africa.

Implications for the broader South African ecological community

Additionally to the development of skills among young scientists in southern Africa, the event stimulated discussions on the need to establish long-term monitoring sites for an improved understanding of grassland and savanna dynamics, and of potential threats to both species and functional diversity. The event also created opportunities for joint efforts to compare African and South American grassy ecosystems.

Anticipated value of this approach to ecological research in South Africa

Resilience of grasslands and savannas

South African grassland and savanna vegetation is resilient to the disturbances, including fire, herbivory and rainfall variability, within which it has evolved. In fact, these grassy ecosystems are dependent on such natural (i.e. endogenous) disturbances. However, the ecosystems are particularly sensitive to human-induced (i.e. exogenous) disturbances such as ploughing, as most herbaceous species are unable to re-establish after long-term changes in the soil.[6,8] Thus, both the evolutionary history and the history of human-induced land-use changes are contained in the below-ground plant traits of grassy ecosystems. As the majority of plants in southern African grassy systems are almost equally dependent on regeneration from below-ground bud banks as from a viable seedbank[6], exploring below-ground plant traits that articulate adaptations and/or sensitivity to endogenous and exogenous disturbances will enhance our understanding of the resilience and sensitivity of grassy ecosystems to global environmental changes[8].

The link between below-ground bud bank studies and ecosystem resilience can be applied at various spatial scales. For example, at community/landscape scale, vegetation state change (such as bush encroachment), biome shifts (particularly what drives the dominance of one life-form over the other), and coexistence of various life forms, can be better understood with knowledge of below-ground plant regeneration strategies. Below the community-level, species-specific responses to both endogenous and exogenous disturbances can inform biodiversity conservation and management practices of southern African grassy ecosystems.

Global change effects

Elevated atmospheric CO_2, climate change, nitrogen deposition, altered endogenous disturbances, anthropogenic land-use change, and alien invasions are well-known drivers of global change. Such disturbances may also impact bud banks. For instance, bush encroachment, partially driven by elevated CO_2 levels, alters natural fire frequencies which may result in a loss of the herbaceous, bud-bearing component. How reduced bud bank resources in bush-encroached grassy ecosystems are linked to changes in regeneration strategies, and hence, to the loss of resilience, remains unexplored in southern African ecosystems.

The C3 herbaceous plants in grasslands and savannas, with their extensive underground structures, contribute substantially to carbon sequestration.[9] This essential ecosystem function provided by the herbaceous communities of grassy ecosystems necessitates the maintenance and conservation of the diverse range of herbaceous functional groups. Land-use change related to losses of accumulated soil carbon, such as ploughing or tilling, is known to have significant impacts on the biodiversity and resilience of grassy ecosystems.[8] However, it is less well known how ploughing devastates the communities of plants who depend on below-ground organs for their persistence.

Effects of invasive aliens or encroachment of indigenous woody plants on plant diversity are well known. However, there is a paucity of information available on the competitive advantage of problem plants over indigenous plant communities as a result of their distinctive below-ground bud regeneration strategies. Moreover, our current understanding of the competitive advantage of problem plants over the natural communities, which relied on below-ground regeneration to persist[10], when indigenous bud banks have been destroyed after exogenous disturbances, is incomplete.

Management

Whether managing for ecosystem services, biodiversity conservation, ecosystem resilience or productivity, we argue that southern African ecologists need to consider below-ground regeneration strategies. For instance, managing for optimal rangeland productivity through bush control will require an in-depth understanding of the below-ground ecology of the particular problem plant. Restoration and rehabilitation efforts should also consider plant regeneration strategies beyond seed banks as many species with below-ground buds are disproportionately contributing to the carbon storage and resilience of grassy ecosystems. This fact also needs to be considered in agricultural land-use expansion. Lastly, southern African grassy ecosystems host a substantial abundance of indigenous food plants and medicinal plants, many of which are harvested for their underground organs, of which the below-ground bud-regeneration strategies need to be understood to ensure sustainable harvesting.

The diversity of below-ground organs in southern African flora and their contribution to ecosystem functioning, necessitate studies focused on below-ground regeneration strategies. Studying bud banks will improve our knowledge on the dynamics of grassy ecosystems, leading to more effective conservation and management of the grassy biomes of South Africa.

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