

Grassland dynamics & bush encroachment in forestry plantations

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I really like grasslands. I especially like how they ripple in waves up and down hill and mountain slopes when there is an approaching thunderstorm; how they change to that rich golden color in the final sunspots just before the dark-grey, rolling thunderclouds and lightning chases you indoors; and how their inflorescences hold rain drops from the previous night like a chandelier of diamonds. My fascination with grasslands extends beyond their aesthetic appearance to also include their ecology, management, and why this matters to forestry.

Moisture and temperature shape grasslands

Grasslands are so vast that we often accept their presence as ubiquitous, yet, they are constantly changing in response to natural and anthropogenic drivers of diversity. I interpret grassland diversity from an understanding that moisture and temperature influenced broad vegetation patterns over the past few thousand years, as outlined by Frank Neumann. Did you know that the current wet-and-warm climatic period has only been around for 800-1000 years? A cooler period with less fires (more than 13 000 years ago) caused grassland to have many more fynbos elements, and we still see relics of Protea and Erica communities growing on cooler, south-facing slopes (Figure 1 above). Much later (~4600 to 3500 years ago), there was a drier period when grasslands saw an increase in karroid elements, specifically *Pentzia incana* (Ankerkaroo) that nowadays dominates sheep farms in the central Karoo.

In the current wet-and-warm climatic period, grasses dominate in grasslands (hence, the name), but they still have to compete with flowering forbs, trees and alien plants to remain numero uno. For this, they use various competitive strategies. Grasses keep flowering forbs at bay by rapidly growing into a dense layer that intercepts heat and sunlight from (s)lower-growing plants. This strategy to monopolize access to sunlight is quite a dicey move, because grasses are themselves not tolerant of shading. In fact, it happens in the absence of fire and grazing that build-up of leaf litter and moribund grass blocks sunlight from reaching live buds and leaves, which causes die-back of grass tussocks – a phenomenon known as 'self-shading'. This is why fire is such an important part of grassland management. Fire is truly the exfoliating treatment that removes dead and dry cells from grasslands, so that new life can flourish.

Importantly, the ability of grasses to outgrow forbs and intercept limiting resources is directly tied to the current climate. During periodic droughts, when grasses cannot maintain their productivity levels, forbs are quite capable of recruiting successfully from seeds. Similarly, grasslands subjected to severe overgrazing are not able to keep forbs in check, leading to an overabundance of flowering forbs that is sometimes even visible on satellite images.

The role of fire

If we shift our focus to the woodies in our midst, grasses keep shrubs and trees in check by sustaining a 'fire trap' from which tree seedlings hardly ever emerge unscathed. A fire trap is essentially the fire flame zone of the grassy layer. Unlike grasses, most indigenous shrubs and trees are sensitive to fire, especially as seedlings. So, fire gives grasses the competitive edge over shrubs and trees, just like climate gives grasses the competitive edge over forbs.

Grassland with a well-developed grass layer that burns at the correct intervals (when biomass ~ 4 tons / ha) should have no problem with invading trees. However, where the grass layer is jeopardized by too frequent burning, overgrazing or shading by large trees, fire intensity will be lower with consequently less killing power to aim at invading tree seedlings. For example, in communal rangeland (with heavier grazing → less grass → cooler fires), it often happens that tree seedlings escape the fire trap and grow into bigger trees that are more fire tolerant. Shading by timber trees also play an important role in advancing bush encroachment into grassland, especially in narrow corridors of forestry plantations. In fact, shading might explain much of the 'edge effect' of timber on adjacent vegetation, previously reported by Prof. James Pryke.

The role of atmospheric CO₂

Interrogations of the local and global drivers of bush encroachment have led to a growing consensus among researchers that elevated atmospheric CO₂ levels is an important global driver of bush encroachment. The exact mechanism is still unknown, but possibilities include the fertilizer effect of atmospheric CO₂ on woody shrubs and trees, or an indirect effect on soil water content and its depletion in the surface soil layers where grass roots sit. Encouragingly though, a team of researchers led by Prof. Sally Archibald and Prof. William Bond found that bush do not encroach as rapidly in protected areas with elephants – the big giants of Africa that create their favored grassland habitat by pushing over trees. Although I am not advocating for the introduction of elephants to eradicate bush, this shows that local actions can trump global drivers in shaping vegetation dynamics. This is indeed encouraging.

Practical solutions customized to local context

The trick is to find practical management solutions that can be applied in forestry plantations to help control bush encroachment. Such solutions will probably involve a combination of management actions sustained for longer periods of time, rather than single once-off interventions. For example, it would be pointless to do a once-off clearing of dense stands of *Ouhout* trees, with no follow-up burning and thinning operations to keep shrubs and trees in check. Moreover, instead of looking for a silver-bullet strategy that works well everywhere, management actions would probably need to be customized to fit local context and challenges.

Key local issues will include the shape and size of conservation areas. By virtue of their close proximity, any management intervention inside a narrow, small or irregularly-shaped conservation area has a greater probability of affecting adjacent timber compartments, than if you had a wider or larger conservation area. Thus, when a decision has to be made to control bush encroachment in one conservation area (but not another), shape and size is a useful starting point. In fact, it is non-negotiable that the conservation area must be the correct shape and of reasonable size to allow for safe burning.

Additional considerations include proximity to important conservation areas (e.g., with Red-Listed species or threatened ecosystems) and level of wetness. If bush encroachment threatens the functionality of a threatened grassy ecosystem, this is a good reason to prioritize bush thinning operations. Even more so when that threatened ecosystem contains threatened species, such as Long-toed Tree Frogs (*Leptopelis xenodactylus*), Swamp Nightjars (*Caprimulgus natalensis*) or African Grass Owls (*Tyto capensis*) that all depend on grassy habitats.

Lastly, level of wetness seems to influence vegetation succession (grassland -> bushy thickets or forest) and / or how the wetland ecosystem responds to bush thinning and burning. This is beautifully shown in the delineated areas of Zululand, where wetter wetlands have a greater tendency to remain grassy, whereas drier wetlands have a greater tendency to become bush encroached. We do not quite understand the mechanism of this phenomenon - it might be that grasses (with shallower roots) respond quicker than shrubs and trees when there is a shallow water table present. If this is the case, it will mean a better ecosystem response to burning, because a healthy grass layer is better able to sustain a fire trap that kills tree seedlings. Personally, I would consider shortlisting wetter wetlands for bush thinning and burning.

The role of roads in shaping fire

It makes logical sense that all management operations should be aligned with clearly-visible, on-the-ground features so that operators know where to work. Such features can be roads, trace belts, streams or fence lines, depending on what is available. Where fire management is concerned, roads (mostly vegetated or dirt tracks) work exceptionally well, because they also provide access to vehicles and fire-fighting equipment, and should have low fuel loads (due to routine road maintenance). This makes it possible for foresters to set alight vegetation along the road, so that the fire burns from the periphery towards the interior of a conservation area, with minimal risk to adjacent timber. This is probably why we find grassland vegetation in larger conservation areas with roads along their edges, but bushy thicket in those without roads (or wrongly placed roads) (Figure 5). Exceptions include narrow or irregularly-shaped conservation areas that will probably not burn, regardless of presence or absence of roads, because of risk to adjacent timber. Another exception is conservation areas on steep slopes, where management (also roads placement and burning) would be adjusted to fit the soil erosion risk profile.

The value of well-placed roads is not new and already embedded in wetland delineation procedures for some forestry companies. Especially in Zululand (where terrain is not a problem), valley-bottom cut-off roads are routinely implemented at the edge of conservation areas (where they join commercial timber) to mark new compartment boundaries, to provide access, and to enable the use of fire in alien plant control (Figure 6). Getting control of alien plants within the first few years after felling timber is a major delineation goal, because it feeds into water security and sets the direction of ecosystem recovery in terms of biodiversity. Most of the roads around conservation areas have vegetated surfaces and are not expensive to maintain (Figure 6), but they make the world's difference in restoring delineated land to a semi-natural state.

I think many environmentally-minded people (including myself) have been blinded by the negative impacts of roads, notably in connection with soil erosion and sedimentation. Perhaps, it is time to recognize that well-designed road networks (with roads that are well-placed, well-drained and well-maintained) can be conservation assets too.

Using fire in alien plant control

Fire, along with foliar herbicide sprays and cut-stump applications are your cost-effective tools in the fight against alien plant invasions, notably American Bramble. Of these, fire followed by foliar sprays is the most cost-effective treatment option available in grasslands, but it is seldom (if ever) used in dense thickets.

Fire in grassland simplifies access, reduces the size of alien plants and causes a flush of new growth, which is more susceptible to foliar sprays than stems and mature leaves. However, of critical importance is the timing of post-fire follow-up sprays to hit the flush of new vegetative growth just at the right time, i.e., when plants are between knee and hip height. Get the timing wrong, and it is back to square one. No alien plant control operation should start without a viable follow-up plan that can be implemented with available resources - money, manpower and the necessary expertise to guide effective alien plant control.

Different stages of bush encroachment

Bush encroachment is a gradual process of indigenous shrubs and trees replacing grasses often over a period of > 10 years. Drought with uncontrolled grazing and shading of the grass layer in narrow corridors can increase the rate of bush encroachment, while expeditious burning can delay or stop the process. At the end of the day, there will be different stages of bush encroachment in a forestry landscape, with at least some alien plants that need to be controlled.

Early stages of bush encroachment (when shrub and tree cover is still sparse) should be prioritized for intervention, because the cost-effective management of alien plants with fire and foliar sprays is still possible. Basically, foliar sprays can be used until alien plants are about shoulder height, but do remember that bigger plants → more herbicide → greater cost. For alien plants above shoulder height, cut-stump applications are your next-best option, but at a far greater expense. Even larger specimens can be frilled or ring-barked, which are labor-intensive and time-consuming operations. Here, you must ensure it is done correctly to ensure maximum effectiveness.

For late stages of bush encroachment (dense thicket or early-successional forest), a different mechanism is used to effectively control alien plants. Here, the tree canopy effectively intercepts sunlight from reaching the soil surface, which prevents alien seeds from germinating. Dense thickets with an intact tree canopy generally do not have a problem with alien plants. It is only where there are gaps in the canopy (due to windfall or along thicket edges) that alien plants can establish, and where they need to be controlled.

A word of caution, though. Chopping down a large, solitary pine or eucalypt tree inside a dense thicket patch will create a gap in the tree canopy that presents an opportunity for alien plant recruitment. It is better to ring bark or frill such trees, so that surrounding indigenous trees are not damaged and so that there is not a sudden flush of sunlight available at the forest floor. The longer 'time-to-kill' for ring barked or frilled alien plant specimens also leaves a window of opportunity for indigenous tree species to fill the tree canopy gap, which effectively removes the alien plant recruitment opportunity. The effective control of alien plants in dense thickets considers treatments along with this careful manipulation of shade and sunlight on the forest floor.

In contrast to early and late stages of bush encroachment, there is an intermediary bushy state that presents a problem to management, and also has less biodiversity value than both more-grassy and more-forested states, according to Dr. René Gaigher. Here, fire cannot be used anymore (due to lack of grass cover) and the tree canopy has not yet locked out sunlight. This stage is susceptible to alien invasion, but it is difficult to gauge extent of invasion due to poor visibility and accessibility. For the same reasons, alien plants are difficult to find and treat. Viable treatment options in this context are expensive and time-consuming: cut-stump applications and frilling. Foliar herbicide spraying is an option along edges, but cannot be recommended for the interior of these bushy patches.

Where it makes sense to do so, the long-term strategy to control alien plants would be to reverse the intermediary bushy state back to grassland, so that fire and foliar spraying can again be used as treatment options. This will also benefit biodiversity. However, it will be an expensive and difficult journey of sustained effort for many years, which necessitates careful consideration of the points raised earlier (size and shape, important conservation areas, slope direction, and level of wetness). For all other conservation areas that is still in a predominantly grassy state, it is of utmost importance to maintain that grassy state with appropriate management.

Grassland for water production

Probably the greatest benefit of functional grasslands in conservation corridors involves their ecological function in the sense of water production. Grasslands use less water than bushy thickets, and much less than alien vegetation. According to the National Water Act (Act 36 of 1998), commercial forestry is a stream-flow reduction activity that requires a water use license to safeguard national water security. It is this legal framework that enforces wetland delineation and control of alien plants along waterways, but it does not stipulate desired natural vegetation type (grassland vs. bushy thickets vs. forest) once timber along streams and around wetlands is felled. If the objective of legislation is to safeguard water security for downstream users, it would seem advantageous to have more grassland and less bushy vegetation in riparian and wetland buffer zones.

However, conservation corridors are not just water production areas. They also conserve biodiversity and ecosystem function, specifically ecological values representative of the historic state before timber dominated these landscapes. If the historic state in Zululand is coastal forest along streams, with grassland a bit further way, there is no reason for bush thinning operations in the riparian zone. Burning of grassland adjacent the forested riparian zone will maintain a functional ecotone and ensure that the coastal forest do not expand to dominate the entire drainage line. Maintaining this natural range of habitat types (grassy and woody types in wetter and drier areas) will tick the 'biodiversity conservation' block along with the one for water production.

A bit of practical wisdom also goes a long way for the management of rugged, south-facing, bush encroached hillslopes in the KZN Midlands. If the terrain is too rugged to have roads (to help safe burning) and if the microclimate on that hillslope is too cold and wet to sustain a fire, it might be best not to intervene with bush thinning operations. However, conservation areas on warmer hillslopes that jut down to rivers and with bush encroachment that can be traced back to a clear starting point (such as a change in ownership or retirement of an experienced forester) are good candidates for bush thinning operations that will probably also benefit water production.

Source: SAForestryonline.co.za