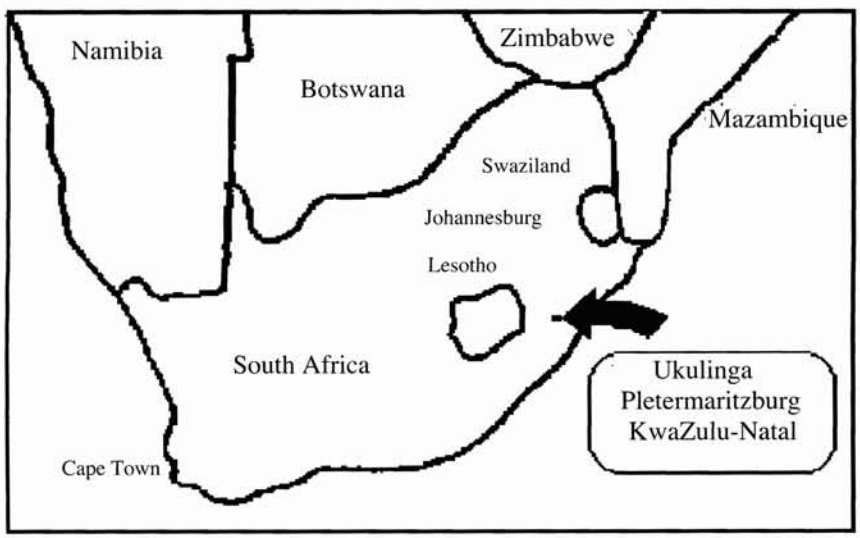
Lessons from Africa

Long-term rangeland trials in an African grassland offer insight on the role fire, fertilizer and rotational grazing play in management of tall grasslands.

By Craig Morris and Neil Tainton

The long-term rangeland trials in tall grassland at the University of Natal's research farm Ukulinga, outside Pietermaritzburg in South Africa, are among the longest running field experiments in Africa. Some of these trials were started in 1950 and have continued uninterrupted since then, providing many useful insights into the ecology of tall grassland and how it can best be managed for livestock production and conservation.

Ukulinga (a Zulu word meaning 'to try') is also the school at which many undergraduate and postgraduate rangeland science students learned their trade (on bended knees and with aching back). Despite the scientific and demonstration value of these trials, they are not well known outside southern Africa. Following, we therefore provide a brief description of some of the more interesting results from fire, rangeland fertilization and grazing trials conducted at Ukulinga that may be relevant to the management of similar grasslands outside Africa.



The Trial Site

Ukulinga is situated in the interior midlands of the province of KwaZulu-Natal, in the south-eastern region of South Africa. Summers are hot and moist (annual rainfall of about 700 mm) and winters are dry and cool with occasional frost. The trial site is located on a flat plateau, 770 metres above sea level, in tall grassveld ('veld' is the local term for range). Tall grassland gets its name from the characteristic tall-stemmed grasses (*Hyparrhenia* and *Cymbopogon* species) that are commonly used for thatching. It is a dense grassland with mostly tropical and sub-tropical grass species, a mix of herbs, and occasional scattered flat-crowned *Acacia* thorntrees.

The two trials that have been running for 50 years at Ukulinga are the Burning and Mowing Trial and the Veld Fertilizer Trial. The Burning and Mowing Trial has 44 treatments (each applied to three, 13 x 18 m replicated plots) made up of combinations of four different mowing times in summer with 11 different winter removal (mostly burning) treatments to remove any left-over material. Burning is applied in autumn, winter or spring at frequencies ranging from annual burning, burning once every two or three years, to those plots that are not burnt or cut at all.

The Veld Fertilizer Trial investigated the effect of different combinations of phosphate and nitrogen fertilizer (of different forms) and liming on the composition and productivity of tall grassland.

Two long-term grazing trials were previous conducted at Ukulinga. One of these trials, which ran from 1958 to 1974, examined the effect of three grazing systems (continuous, rotational stocking and rotation seasonal rest) stocked with sheep at three different rates on tall grassland. A second, 24-year trial (1967-1991) tested nine different rotational grazing systems for sheep made up of combinations of three different periods of occupation

Fifty years of fire exclusion has allowed indigenous and exotic trees to invade tall grassland.

of each paddock (2,10 and 20 days) and three periods of absence from the grazing paddock (20, 40 and 60 days). This trial provided a means of examining the usefulness of multi-paddock systems for grazing management of tall grassland.

Various cutting trials, some as long as 15 years, were also conducted to explain some of the results emerging from the long-term trials. These studies contributed greatly to a detailed understanding of how and why various important grass species react to being defoliated and how certain traits enable some species to withstand frequent defoliation by fire, grazing or mowing. A comprehensive list of these and other grassland studies conducted at the Ukulinga research site is provided by Morris and Fynn (2001).

What effect has fire had on tall grassland?

Fire has been a common feature of the African landscape for millennia. It is not surprising, therefore, that the Burning and Mowing Trial clearly demonstrated that tall grassland, similar to many other African grasslands, is adapted to, and maintained by, frequent fires. We would go so far as to conclude that fire is in fact not a disturbance to tall grassland but rather an essential, integral component of its function and ecology.

Fire during the dormant season destroys leaves and shoots of grass plants but the mainly perennial grass species found in pristine tall grassland survive and thrive (through increased shoot production and soil nutrient cycling rates) under a frequent fire regime.

What evidence have we to conclude that the existence and ecology of tall grassland is so closely tied to fire? First, removal of fire in the Burning and Mowing Trial had a dramatic effect on the overall makeup of the grassland. Excluding fire for five decades allowed indigenous *Acacia* and broadleaf trees as well as numerous exotic woody species to invade (See photo 1). Course, unpalatable wiregrass (*Aristida junciformis*, locally called Ngongoni), with a low overall basal cover, has replaced the dense original grassland dominated mainly by redgrass (*Themeda triandra*) and speargrass (*Heteropogon contortus*).

The Burning and Mowing Trial also showed that the reaction of species to fire follow the classical Decreaser-Increaser response patterns described in the oft-criticized Range Succession Model. Grasses that dominate

tall grassland in good condition (in terms of soil cover and value for livestock production) are most abundant when the grassland is burnt often. Redgrass, for example, reaches its maximum abundance when burnt every year in winter and mown at least twice during the summer growing period.

Burning only every three years has changed the composition and structure of tall grassland (background) compared to grassland burnt and mown annually (foreground).

If tall grassland is not grazed or burnt for a few years, however, the dominant grasses become moribund and eventually die out through self-shading. They are succeeded by less palatable and less productive species such as trident grass and the taller thatching grasses which increase in abundance with infrequent burning (See photo 2). Grass basal cover also declines with infrequent burning, which could have an important impact on soil conservation.

How often should grasslands be burned?

The optimum burning frequency to maintain the composition, cover and overall species diversity of tall grassland (with light or no grazing) is about once every two to three years (See photo 3). The Burning and Mowing Trial has also clearly shown that burning must be applied during periods when plants are dormant as fires during the growing season will kill many grass species and reduce overall sward cover.

Regular burning (annual or biennial) is necessary to maintain the diversity and cover of tall grassland.

Grasslands of southern Africa with more moisture, including tall grassland, are described as 'sour' grasslands (sourveld) because the nutritive quality of the forage they offer deteriorates markedly from mid-summer onwards as grass tufts mature. As a consequence, sourveld, unlike the semi-arid 'sweet' grasslands (sweetveld) of South Africa, is not sufficiently nutritious to support livestock for the winter period without some supplementary feeding.

Fire is an essential tool for the management of sourveld. Farmers burn to remove old, unpalatable herbage and to provide fresh, green material for spring and summer grazing. Experiments at Ukulinga showed that such burning reduced the total amount of herbage produced in the season following the burn. However, this suppression of production was not permanent and grassland burnt regularly will, on average, produce more useable forage than grassland burnt infrequently or not at all.

Is it necessary to fertilize tall grassland?

The original aim of the Veld Fertilizer Trial was to test whether forage production of natural grassland could be increased by adding fertilizer (to inherently acidic and infertile soils), but it has also provided insights into how these grasslands function and how grass species respond to different types of fertilizer.

Adding nitrogen and phosphorus to tall grassland did increase herbage production but fertilization also

totally transformed its composition. The original dominant grasses have been replaced by species that are commonly found in fertile environments (such as under trees, in old lands, etc). These changes resulting from fertilization are similar to those brought about by improper grazing, with Decreaser species (e.g. redgrass, speargrass) being replaced by nitrogen-loving species such as guinea grass (*Panicum maximum*), weeping lovegrass (*Eragrostis curvula*) and common paspalum (*Paspalum dilatatum*).

Of all the fertilizer elements, nitrogen had the greatest influence on the composition and productivity of tall grassland, but its interactions with other applied fertilizers (especially phosphorus and lime) produced quite complex changes in composition that were not anticipated at the start of the trial.

These, and results from other rangeland fertilizer trials conducted elsewhere in South Africa, have clearly indicated that it is not economically viable nor ecologically desirable to fertilize native grassland to increase forage production. Natural grassland can be completely and irreversibly transformed by fertilization and the increase in forage production does not warrant the costs incurred.

An important lesson is that grazing trials should be conducted over a lengthy period - not shorter than 10, and perhaps longer than 20 years

How does grazing affect tall grassland?

Cattle, and especially sheep, graze very selectively in tall grassland—and indeed in all sourveld—because of the wide range in palatability of grasses occurring in any one grassland and because the acceptability of species to livestock changes (at varying rates for different species) over the season.

Long-term grazing trials at Ukulinga demonstrated that selective grazing can rapidly degrade redgrass-dominated tall grassland to a stable but unproductive state dominated by coarse, perennial Increaser grasses. The debate whether continuous (set stocking) or rotational stocking is better for management of South Africa's rangelands still continues. However, at Ukulinga, rotational stocking was the only way to maintain tall grassland in its original productive state.

We have also concluded, from a study on different types of rotational systems, that rotational stocking systems need not be complex multi-camp systems, but require only a few camps (certainly no more than eight per herd/flock) to achieve their objective.

An important lesson is that grazing trials should be conducted over a lengthy period—not shorter than 10, and perhaps longer than 20 years—to detect crucial changes that might happen only after a long period of grazing.

Some changes as a result of grazing occurred early during our trials. For example, when heavily stocked paddocks were given a rest in spring after three years of intense grazing by sheep, seedlings of the highly unpalatable perennial grass, *Aristida junciformis* (wiregrass) established and had time to grow large enough to escape further grazing, eventually resulting in wiregrass-dominated grassland that was completely useless for livestock production.

In contrast, invasion by wiregrass was much slower under other grazing treatments but the end result was the same. It seems that improper grazing, especially if it is concentrated on a few species, may eventually push tall grassland over a threshold, beyond which recovery to the original state is impossible without costly and time-consuming rehabilitation procedures.

Giving improperly grazed rangeland a long rest to restore the vigour of any remaining palatable species and to speed up rehabilitation could, however, be a mistake. When sheep were removed from paddocks that had been degraded by more than a decade of heavy continuous stocking to a short, unproductive sward, wiregrass rapidly invaded these paddocks, degrading them even further.

We have learned a lot at Ukulinga about how to degrade grassland, and the role of selective grazing in this process, but more research is now needed on how grasslands recover from improper grazing and if recovery can be assisted by specific rehabilitation practices (such as reseeding or replanting lost species).

The future of the Ukulinga trials

At Ukulinga we are currently studying the effects of five decades of fire and mowing treatments on seasonal changes in forage quality, soil fertility and soil nutrient cycles as well as the effects of fire and mowing on the overall biodiversity of tall grassland. Similar studies done at various sites in the prairies of the USA have provided a detailed overall understanding of how prairies function under different disturbances.

The Konza Prairie rangeland experimental site in Kansas, for example, is one such Long-Term Ecological Research Site (LTER) where myriad aspects of grassland ecology have been studied (visit the Konza website at http://www.konza.ksu.edu/ [accessed 04/29/02]). The

existing long-term trials at Ukulinga offer similar opportunities for international collaborative research and education programs to provide a detailed understanding of how African grasslands work, and how they can be managed for sustainable livestock production and biodiversity conservation.

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Suggested Readings

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