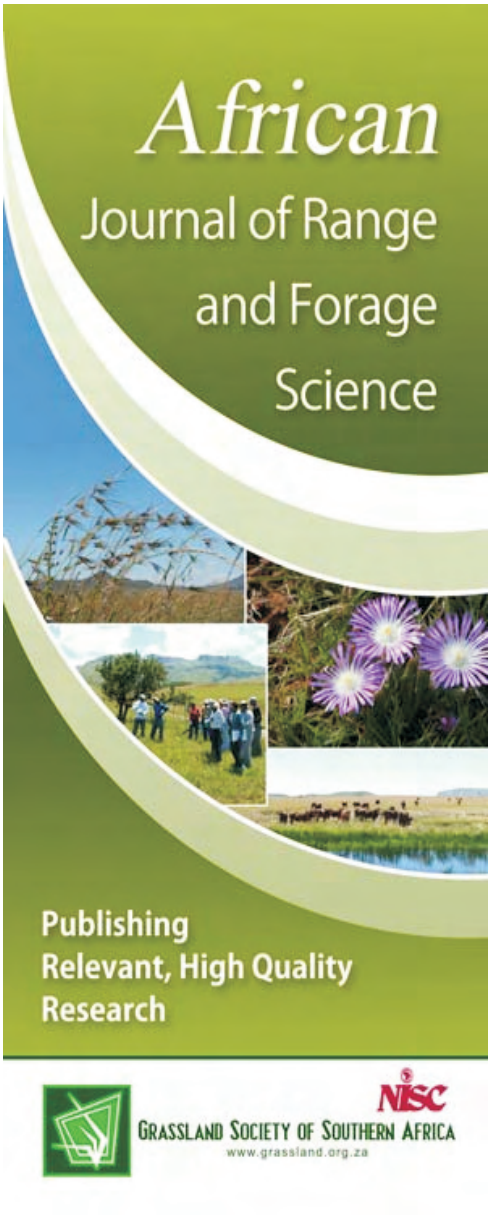

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Editor's Note

Welcome to the first issue of Grassroots for 2016.

Grassland and pasture scientists have been exceptional newsmakers over the last three months and this issue is packed with news reports relating to the interest of grassland scientists. This issue contains numerous news articles on climate change, the new development goals, soil erosion and global food security, wetlands and more.

Furthermore, this issue contains three feature articles. The first relates to applying key concepts to achieve optimal rangeland management, by Richard Fynn. This paper relates to the paper presentation for which he gained the award for the best presentation at the 50th GSSA congress. The second is on the use of native shrubs in drought-stricken crops in Sub-Saharan Africa, an articlewhich may be relevant for many who experience the drought currently. The third article is a commentary article on why smart agricultural development is needed in Africa's savannas. Apart from the news snippets and feature articles, this issue also informs the members of the GSSA of opportunities and events for Grassland Scientists. Make sure you register on time for the GSSA congress in July this year in Wilderness, Western Cape – You will find deadlines and information about registration inside the front cover.

Thank you to those who contributed to this issue. Enjoy reading it!

Dr. Pieter Swanepoel

Umgano State Forest celebrates the 111th anniversary of its proclamation

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This year marks the 111th anniversary of the proclamation of Umgano State Forest, which makes it one of the oldest protected areas in KwaZulu-Natal Province – only nine years younger than the first to be declared, St Lucia Game Reserve. It is relatively small in size, only 128.54 ha, but it conserves one of the most important indigenous forests in the province, if not in the country. It is entirely surrounded by the Umgano Project Area, and while the State Forest is State land in the custody of the Department of Water Affairs and Forestry, the Umgano Project of the Mabandla Community is playing an important role in its protection, in particular in helping to protect it from the fierce wildfires that seasonally ravage this area. The main vegetation type of the Umgano Project Area is grassland, but there are also a number of Southern Mistbelt Forests (evergreen Podocarpus high forest) which are located in refugia within the project area in the general vicinity of Umgano State Forest.

Other forests to the north and south of the project area are sufficiently close for regular local migrations of forest birds to take place, thereby providing important ecological benefits such as the exchange of seed of forest plants between the forests. This forest type is one of the most threatened in the MPA Hotspot and the individual forests are of great intrinsic value, but are also valuable from a payment for ecosystem services delivery perspective. A survey was recently commissioned by Ezemvelo KZN Wildlife for a study of the indigenous forests that are spread in an arc along the foothills of the Drakensberg Mountains, between Bulwer and Ngeli, near Kokstad.The study was undertaken by Adie et al.(2013). Amongst the findings of the study are that they consider Umgano Forest to be one of the best conserved forests in the province, if not in the country. Umgano Forest has somehow escaped early colonial logging but also has remained largely free of contemporary community tree extraction. They found some evidence of timber and pole extraction, but report that this is localised and limited. They also found that above-ground biomass (therefore organic carbon) to be more than double that recorded in typical Mistbelt Forest elsewhere in KZN - of significance from a carbon sequestration payment for ecosystem services perspective. The forest contains a number of trees of exceptional size.

One individual Afrocarpus falcatus had a diameter at breast heightof 166 cm and a height of 32 m. Umgano Project field staff have recently found other exceptionally large yellowwoods, which have been submitted to the Department to determine whether they qualify for Champion Tree status. These authors consider that Umgano Forest is a national treasure and should be treated as such. The portion of the Umgano Project Area in which the SF is located is the Natural Zone, which is shortly to be designated as a nature reserve under the NEM: Protected Areas Act, which should provide a further level of protection for it.

Adie H., Rushworth I & Lawes M., 2013. Pervasive, long- lasting impact of historical logging on composition, diversity and above-ground carbon stocks in Afrotemperate forest. Forest Ecology and Management homepage. <wwwelsevier.com/locate/foreco>, pp 888-895.

SAEON launches new study on climate change impacts in southern Africa

SAEON eNewsletter
December 2015

A group of South African scientists have presented radical evidence of fundamental changes in African ecosystems, which threaten the future of our savannas and their wildlife. Unlike in the northern hemisphere, the global driver that has the largest impact is not global warming, but increasing carbon dioxide in the atmosphere. Increasing CO_2, the scientists argue, is altering the balance of trees and grasses to favour trees - causing savannas to close up and form dense woody thickets. "Savannas were born under low atmospheric CO_2 and could disappear under high CO_2," says Professor William Bond, SAEON's Chief Scientist. Indeed, simulation models designed for African vegetation predict that savannas will be replaced by scrub woodlands and thickets by the end of the century. Land users have long been aware of 'bush encroachment'. Dense bush on one side of a fence and open grasslands on the other is a familiar indicator of the importance of land management in structuring our ecosystems. "But where once we could blame the land user for mismanagement, we now have to blame the additional effect of a global driver, increasing CO_2, a by-product of industrialisation, promoting tree growth to a level never seen before," says Professor Guy Midgley of Stellenbosch University.

Unexpected impacts in the Karoo

Ironically, while savannas and grasslands are turning into woodlands and thickets, the arid shrublands of the eastern Karoo are being invaded by grasses. For the first time, farmers have to cope with grass-fuelled fires as a result. Again, land management, through livestock farming, strongly influences the process but the shift to grasslands is new and unexpected. "Unlike global warming, where the main intervention is reduction in greenhouse gas emissions, there is considerable scope for managing our ecological futures in South Africa," says Dr Nikki Stevens of Stellenbosch University. The old tools, fire and herbivory, will not work in the same way as in the past, but radical new ways of using them are already being developed in South Africa. "The benefits of maintaining our grassy systems are many," says Dr Luthando Dziba of the CSIR. The game industry and associated tourism alone is worth billions of rands. Livestock farming, which depends on grass, contributes to national food security.

Further strain on water supply

Our water sources for the major industrial centres originate from the grasslands of high mountain ranges. Experimental studies of afforestation have shown how tree planting in the grassy catchments reduces water flow. In our water-scarce country, invasion of grasslands by trees would put further strain on water supply to cities and industrial centres. But the rise of trees also presents economic opportunities. Biomass burning, charcoal production and hardwood trees for high-value products need to be explored as new avenues for job creation. Tree invasion in semi-arid areas may also be turned into economic opportunity by developing the small livestock industry in poor rural communities, supplying livestock to urban areas and for export.

Early warning of future changes

"This national analysis, the first of its kind, not only shows the major changes that have happened in our summer rainfall regions over the last few decades, but is an early warning of future changes," says Professor Timm Hoffman of the University of Cape Town. South Africa has an impressive track record of managing national environmental issues as seen in the analogous problem of alien invasive plants. 'We feel that South Africa has the capability to tackle these profound ecological changes to our benefit," says Dr Dziba. This radical new view of how global change plays out in South African ecosystems is of wider relevance to much of Africa, which has the most extensive savannas of any continent. Global change impacts on African systems are quite different from those of the cool temperate regions of the world, the source of so much global change science and policy.

Long-term datasets

"We need to develop credible science, based on our wealth of long-term datasets, and policies and actions relevant to South Africa's needs," says Professor Bond. The results of the study have been published in a new publication, Change is in the Air, which was launched at the Department of Science and Technology's first Science Forum on 9 November 2015. The publication is available to download on the SAEON website:
http://www.saeon.ac.za/projects-andpublications/Change%20is%20in%20the%20air_WEB%20VERSION.pdf

Science underpins new development goals

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Negotiators of the Sustainable Development Goals (SDGs), adopted in September 2015, in New York, have stressed the role of science in meeting the wide range of concerns that the new goals aim to address by 2030. More than 150 heads of state and government, as well as high-level representatives, attended the UN Sustainable Development Summit (25-27 September 2015) and unanimously approved Transforming our world: 2030 Agenda for Sustainable Development. The agenda includes 17 SDGs (and 169 targets) — nine more goals than the Millennium Development Goals (MDGs) agreed in 2000.

They cover issues such as conserving the oceans, protecting biodiversity, ensuring access to energy and "taking urgent action on climate change". Flavia Schlegel, assistant director-general for natural sciences at UNESCO (UN Educational, Scientific and Cultural Organization), stated that they are an "inspiring package of goals" and owe much to underpinning scientific evidence. "They are very comprehensive and really cover the most important aspects of life on this planet — for plants, animals and human beings," she tells SciDev.Net, adding that the goals' diversity also means that "they are all interlinked". At the UN conference, Schlegel drew attention to the important role that science will play in the post-2015 development agenda: "Goals [about] water, energy, biodiversity, ocean and climate change are heavily dependent on science, but there is also a cross-cutting issue through the whole agenda —that science, technology and innovation will really be a driving force for development." Romain Murenzi, executive director of The World Academy of Sciences, mentioned the 2030 development agenda is a comprehensive plan for national and global socioeconomic development, but needs to be backed up with sufficient finance.

"It will require greater investment in education at all levels,". "It will also require investment in science, technology and innovation not only for economic growth, but also social inclusion — that is, the eradication of extreme poverty through access to food, safe drinking water and sanitation." Murenzi adds that including people of the developing world in science and

fostering South- South collaboration is essential to ensuring that knowledge from all over the world is taken into account when the goals are implemented.

"Some countries in the south, such as Brazil, China, India, South Africa, Mexico and Turkey, have had tremendous economic development and also tremendous advances in science and technology," Some researchers and policymakers are concerned that the large number of targets and indicators within the goals could be confusing. Harald Schmidt, a health policy academic at the University of Pennsylvania, United States, stated that within the health goal, for example, it would make sense for policymakers to prioritise the targets that benefit the worst-off groups. He stresses the need for practical guidance for policymakers who may struggle to understand and incorporate relevant scientific evidence and apply it fairly across their policies. The next step in the 2030 development agenda will be defining indicators to measure whether the SGDs are progressing or not, which are expected to be published by September 2016.

"They are very comprehensive and really cover the most important aspects of life on this planet — for plants, animals and human beings." - Flavia Schlegel, UNESCO.

Soil erosion may threaten global food security

Joe Turner
Science Journalist

Global soil erosion has reached levels that will endanger humanity's ability to feed itself if nothing is done to lower it, a study warns. The review, published in Science 8 May 2015, mentions that soils are being lost faster than they are being naturally produced in many parts of the world. In addition, there is increased pressure on farmland from non-food uses, such as crops being grown for biofuels, and there may be future shortages of rock phosphate, which is used to make fertiliser. Ronald Amundson, a soil scientist at the University of California, Berkeley, in the United States, and one author of the study mentioned that "The increases in food production in the developed regions of the world are plateauing".

He also believes that "There are opportunities to increase food production in underdeveloped nations, but this will require expenditures for fertilisers to bring their yields up to what the regions can potentially produce." The phosphorus needed to create fertiliser is mined. This raw material has risen in price recently, according to the paper, prompting worries about the availability of inorganic fertilisers for farmers in developing countries. The paper's authors say that, instead of relying solely on fertiliser to increase yields from conventional farming, more efficient food distribution and nutrient recycling are needed to end hunger — one of the UN's proposed Sustainable Development Goals (SDGs). Soil erosion is caused by the overuse of land, deforestation, desertification and water runoff — all of which are, to some extent, caused by farming.

The Science paper comes as many scientists worry that soil protection targets in the draft SDGs may be removed from the final list of goals. Since January, which marked the start of the International Year of Soils, scientists have been calling for greater political focus on soil management. According to Tim Benton, a population ecologist at the University of Leeds in the United Kingdom, better soil management could go a long way towards producing enough food in the future. "I don't think we worry enough about conserving soil resources for the long term,". Rattan Lal, a soil scientist at The Ohio State University in the United States mentioned

that in traditional farming systems, food production can be increased by using various techniques to reduce soil erosion, . For example, farmers can preserve their soils using agroforestry and by covering it with crop residues.

But it is a major decision to switch to such methods, as these are more labour intensive and can be less economically efficient, considering many farmers use agriculture to meet household needs for feed, fodder and building materials. According to Lal, around 500 million farmers worldwide depend on farms of less than two hectares. If soil management were included in the global agenda to address climate change and food shortages, much could be done to help the two billion 'hidden hungry', who are not eating enough nutrients in their food.

"I don't think we worry enough about conserving soil resources for the long term."
- Tim Benton, University of Leeds.
"The degradation and loss of soil around the world."
Ronald Amundson and others Soil and human security in the 21st century (Science, 8 May 2015)

The degradation and loss of soil around the world
Ronald Amundson and others Soil and human security in the 21st century (Science, 8 May 2015)

VEGMAP 2012 beta App. version released on bgis.sanbi.org/

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The latest online version of the National Vegetation Map of South Africa, Lesotho and Swaziland was recently released on bgis.sanbi.org. VegMap2012 incorporates all edits since VEGMAP2009 (additional vegetation types, deleted vegetation types, and altered boundaries to existing vegetation types).

A mobile version of the 2012 VEGMAP was also released this year using CarryMap Observer as a platform. This mobile version has been designed for use in the field on an android cellular phone. The app can track your location as you move across vegetation types. You can also tap the screen to access the attributes of a vegetation type. Placemarks with comments can also be saved by pressing and holding the screen. A visual quick guide to downloading and using some of the app functions is illustrated below.

Soil project seeks to soak up extra carbon

Tania Rabesandratana
Science Journalist

[PARIS] France is leading a worldwide push to increase the amount of carbon locked in soils through better farming practices. Supporters of an initiative launched at the COP 21 summit say this would limit global warming by removing carbon from the atmosphere, while also increasing the range and amount of food farmers produce by improving soil fertility. This would particularly benefit developing countries, according to representatives of the 4 Pour 1000 initiative. "It's a bit of a scientific dream, but we have a lot of evidence that supports this dream," Jean- Paul Moatti, the chief executive officer of the French Research Institute for Development, one of the organisations behind the plan, said yesterday on the sidelines of the talks in Paris, France.

Increasing carbon stocks in the top 40 centimetres of soil by four parts per 1,000 (0.4 per cent) each year would compensate for carbon emissions from human activity, the project description says, provided deforestation is halted. To achieve this, the plan suggests five practices: not leaving the soil bare, to curb carbon losses from erosion; restoring degraded land; planting trees and growing legumes that increase levels of the plant nutrient nitrogen in the soil; feeding soil with manure; and conserving water at the base of plants to boost their growth. Dennis Garrity, a dryland ambassador for the UN Convention to Combat Desertification, said the plan could transform agriculture in the same way that renewable energy advances help change energy systems. Farmers are already trying to introduce new practices, said Edwin Castellanos, director of the centre of environmental studies at the Universidad del Valle in Guatemala.

"The big challenge lies with small farmers" who lack the access to finance and technological support that big businesses have, he told the event. In Guatemala, attempts to charge consumers a premium for coffee grown on more environmentally friendly fields has only had "limited success", Castellanos explained. The problem is that farming must remain commercially competitive, he said. The 4 Pour 1000 proposal consists of a voluntary action plan and research programme.

The programme does not yet come with a budget or timeline, but Moatti told SciDev. Net he was confident it would secure funding from international sources such as the UN Framework Convention on Climate Change's Green Climate Fund. But a group of humanitarian and development NGOs called Coordination SUD have raised concerns about the type of funds that may be used to finance the initiative.

It fears that without proper oversight, the use of private sector funds could lead to land grabbing. Partners in 4 Pour 1000 include research organisations, the governments of Costa Rica, Ethiopia, Morocco and Uruguay, the World Bank and the UN Food and Agriculture Organization, as well as businesses and NGOs.

"It's a bit of a scientific dream, but we have a lot of evidence that supports this dream." Jean-Paul Moatti, French Research Institute for Development.

Ingula Wetlands Walk 2016

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On Saturday, 13 February 2016, 210 people gathered on a perfect summer morning for a nostalgic walk through the Bedford Dam basin. They were surrounded by a sea of shimmering green grassland alive with buzzing insects and hundreds of Amur falcons perching, hovering and weaving through the air to fatten-up on the summer insect-feast. During summer-time birdlife at Ingula is spectacular, with 306 species already sighted in the reserve area. The abundant biodiversity of Ingula is one of the reasons for the walk – and to observe World Wetlands Day which is celebrated during February every year.

Ingula is the custodian of over 1 000 hectares of wetland. This year's walk was the sixth walk hosted at Ingula and three routes were specially selected to demonstrate the ecological value of Ingula. Within a few months the Bedford Dam basin would be underwater and people would not be allowed to walk through it again for safety reasons. The large group contained three local schools: Isiqopamithi Primary School, Nakekela Ecowarriors from Van Reenen and the matric class from Ladysmith High school.

Amongst the participants were members of the Ingula Partnership made up of Eskom, and prominent conservation NGO's, BirdLife South Africa and Middelpunt Wetlands Trust. The balance of the walkers were made up of local people, and several people from as far as Johannesburg to participate. Three walkers were eighty years and older! The Ingula Visitors Centre conducts tours of the construction site and conservation area on weekdays.

Presentations can also be given off-site. Booking in advance is essential. Contact:
Tel. 036-3423236 or 036-3423122 Email: ingulavisitorscentre@eskom.co.za

Applying key concepts to achieve optimal Rangeland management

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The debate about optimal methods of rangeland management rages on unresolved. Several syntheses of numerous grazing experiments have failed to find any advantages of rotational grazing systems over continuous grazing systems. While rotational grazing was considered to be a scientifically superior approach to rangeland management, a deeper examination of several key concepts in grazing ecosystem ecology demonstrates that rotational grazing falls short of scientific and ecological correctness. Holistic planned grazing (HPG), though not rotational grazing, also relies on the regular movement of livestock across the ranch according to the ranchers grazing plan. I will show in this article that HPG suffers from the same key conceptual flaws found in rotational grazing.

Like rotational grazing, HPG attempts to minimize selective over-grazing of palatable grasses and under-grazing of unpalatable grasses, while ensuring that grasses are afforded a long recovery period after grazing, which are both important goals. However, achieving these goals, especially without negatively impacting animal production, requires a fundamentally different approach to grazing management than the approaches used by rotational grazing or HPG, which will be discussed later. HPG also incorporates the appealing concepts of simulating the movements and grazing and trampling impacts of large herds of wild herbivores that once roamed African grasslands and savannas in vast numbers, exerting positive effects of breaking soil crusts, burying seed, fertilizing with dung and urine and non-selectively grazing down all the grass tufts in the landscape. These effects are certainly important for increasing rates of nutrient cycling and grassland productivity, while facilitating establishment of new seedlings and are supported by science.

However, it is proposed by HPG that vast herds moved into an area grazed down all the grass and then moved on, leaving the grazed grasses to recover for long periods. In reality herbivore use of landscapes is far removed to what is proposed here (as will be shown later) and any grazing management strategy based on this erroneous concept of herbivore grazing ecology is conceptually flawed and likely to result in sub-optimal outcomes. Unfortunately many ranchers are lured into taking up HPG because the concepts sound so appealing, but

without sufficient knowledge in grazing and herbivore ecology, they are unable to adequately assess the validity of the ideas and concepts being promoted at holistic management workshops. In an attempt to assist people to understand why both rotational grazing and HPG fall short of ecological correctness and, therefore, are sub-optimal strategies for managing most rangelands I will now describe four key concepts, which form the pillars of healthy and productive grazing ecosystems and herbivore populations. I will also attempt to show the way forward and what I believe is the future of optimal rangeland management.

THE KEY CONCEPTS

CONCEPT 1: Carrying capacity is strongly driven by grass productivity. There is a positive linear relationship between grass production (kg ha^{-1}) in various national parks across Africa and the amount of large herbivore biomass supported by those parks (Fritz & Duncan 1996). This is fairly obvious but the implications are that carrying capacity is not a constant but can be increased or degraded by increasing or decreasing grass productivity on the ranch.

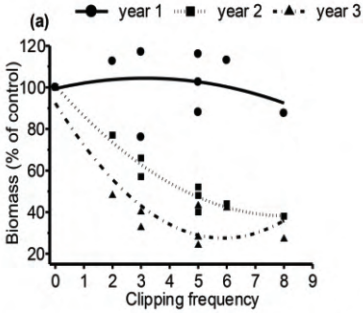

Figure 1: Effect of clipping of grasses on next seasons productivity (redrawn from Turner et al. 1993). Note how clipping grasses in the first year did not reduce productivity because the grasses had rested in the previous year but that productivity declined greatly when grasses had been clipped in the previous year (year 2 clip) and even more if clipped for the previous two years (year 3 clip).

CONCEPT 2: Clipping and grazing studies have demonstrated that current growing seasons grass productivity is strongly driven by the amount of grazing grasses received in the previous growing season (Turner et al. 1993; Kirkman 2002) (Figure 1). Rotational grazing violates this principle by grazing all paddocks across the ranch each growing season, thereby reducing optimal recovery periods for grasses. This may lead to reduced grassland

productivity and reduced abundance of palatable perennial grasses. Removal of leaves during grazing results in loss of key growth-limiting nutrients such as nitrogen, which must be recovered by the grass plant to avoid declining productivity. Most nutrients are made available for plant uptake during the early wet season when the peak of the mineralization process occurs (mineralization is the microbial conversion of minerals stored in an organic form in plant residues in the soil to a mineral form, which is available for plant uptake). Regrowth of grasses after grazing is made possible by remobilizing growth-limiting nutrients stored in root biomass to produce new leaves with the implication that productive grasses have large root systems. However, root biomass develops mainly over the late wet season

(McNaughton et al. 1998; Snyman 2005). The implication of this is that grasses need a full year's recovery period to enable maximum uptake of growth-limiting nutrients in the early wet season and maximum storage of these nutrients as root biomass in the late wet season. Such grasses will be extremely productive in the next growing season (Turner et al. 1993; Kirkman 2002).

CONCEPT 3: Optimal cattle production is achieved by ensuring that grass height/maturity is kept at an optimum to maximize quality (energy and protein content and digestibility) and intake rate. Rotational grazing violates this principle by providing long recovery periods between grazing events, which allows the grass to mature beyond the optimum stage for grazing. Studies done at Dohne Research Station in the Eastern Cape show that allowing grassland to mature before grazing can result in up to a 60 % reduction in weight gain of sheep (Zacharias 1995). Poor nutrition also has other negative effects on animal production such as reduced birth rates and calf size at birth, while age at first conception is increased (White 1983). This explains why many HPG ranchers battle with achieving high conception and birth rates and why there is an increased need for lick supplementation (Gressman & Gressman 2011). Thus rotational grazing strategies and HPG, which allow long recovery periods between grazing events have three main negative effects on ranch productivity: (1) reduced animal production, (2) increased need for lick supplementation with associated costs and (3) reduced grass production because of aging leaves and increased shading by litter. These all reduce the productivity and profitability of the ranch. Thus optimal grazing management should aim to maintain sufficient grazing intensity over the growing season to maintain the grass sward at an optimal height and state of maturity for maximum animal production.

CONCEPT 4: Maximum stability and productivity of herbivore (cattle) populations is obtained by movement between a shorter but higher-quality wet-season range and a taller, but lower-quality dry-season range (Owen-Smith 2002, 2004). All known wild herbivore and

transhumance migrations in Africa follow such a grazing pattern (Fynn & Bonyongo 2011), indicating that there is an obvious biological advantage to such a pattern – if the long-term viability and success of herbivore populations depends on such a grazing pattern we need to take note and learn. The causative mechanisms are that the high-quality wet-season range maximizes energy and protein intake for growth and reproduction while the taller dry-season range provides a reliable forage reserve over the resource-limited dry season, especially during droughts, thereby minimizing weight loss and mortality. Drawing on concepts 3 and 4 it becomes apparent that wild herbivores will seek to forage in grassland of optimal height and maturity where their intake of energy and protein is maximized. Thus wild herbivores will rarely follow a grazing pattern promoted by rotational grazing, especially that under HPG, where grassland is rested for months before cattle are allowed to regraze it. In reality, studies of wild herbivore grazing ecology show that wild herbivores prefer to forage in highly digestible, immature grassland after fire or grazing has removed the older low quality material (Figure 2).

Figure 2: Buffalo in Kruger National Park selecting for high-quality, leafy regrowth of perennial grasses after fire. Herbivores will not follow a grazing pattern promoted by rotational grazing and HPG where livestock are moved into paddocks with grown-out low quality grass (developed after months of resting) and then moved before they can benefit from the fresh leafy regrowth.

Thus wild herbivores prefer to return to grazed areas to regraze the highquality regrowth – a concept known as grazing facilitation. The claims of HPG that it attempts to simulate natural grazing patterns by moving large herds of cattle into grown-out veld (from a long rest period) and

leaving them there for a short period without opportunity to benefit from the high-quality regrowth after grazing, are, therefore, in error. As such many HPG ranchers have built their grazing strategies on false concepts with negative consequences for cattle production and profitability (the same can be said of most rotational grazing strategies). Unfortunately most ranchers (or even rangeland scientists) are unable to evaluate the validity of ideas promoted in HPG or rotational grazing because of the need for specialized technical knowledge in herbivore
grazing ecology to shed clear light on such issues.

THE WAY FORWARD

Clearly the way forward is to incorporate the four key concepts that have been laid out above into a new optimal rangeland management strategy that, unlike HPG and rotational grazing, does not violate these key concepts. Such a strategy must aim to provide year-long recovery periods for perennial grasses (for optimal range condition and productivity), while at the same time ensuring that grazed portions of the ranch are maintained in an immature, high quality state over the wet season (for maximum cattle production). To achieve this, the ranch should be divided into a grazed half and a rested half, switching each half between the two states (rested vs. grazed) in alternating years. All the cattle on the ranch are concentrated on the grazed half of the ranch for a full year to (1) allow for sufficient sustained grazing pressure to maintain grassland in an immature, rapidly-growing and high-quality state, and (2) to ensure a full-years recovery for grasses on the ungrazed half of the ranch. Resting half the ranch for a full year also allows grasses to maximize seed production for new seedling establishment (grazing greatly reduces seed production). Owing to the year-long recovery period, grasses have developed a large reserve of forage, which supports the cattle over the dry season and are so productive that they easily support the entire ranches cattle population for the wet season. As such the rancher has built in fodder flow insurance and less reliance on supplementary feeding, thereby maximizing profits.

Profits are further maximized by much less reliance on a complex system of internal fencing, which greatly eats up profits (Bracy Knight et al. 2011), while greatly reduced forced movement of cattle between small paddocks results in much less management and labour requirements and reduced interference on cattle optimal foraging ecology. It is better to give cattle freedom to range over larger areas allowing them to select spatially for optimal resources according to their specific needs (adaptive foraging) rather than forcing them to be where they don't want to be by continually moving them through restricted paddocks, which greatly restricts optimal resource selection and increases stress on the animals. Holistically speaking, the split ranch strategy is optimal, both ecologically and economically, as well as for overall quality of life for man

and beast.

The exact configuration of the grazed and rested portions of the ranch is up to the needs of the rancher, from at its simplest form the ranch consisting of only two paddocks (a grazed and rested paddock, alternating between years) (Figure 3A) to more complex designs where the ranch is divided into several cells consisting of grazed and rested paddocks where each cell contains its own herd to allow separation of breeding herds, weaner herds and bull herds, according to the needs of the rancher (essentially each cell is its own micro-ranch) (Figure 3B). However, it is best to keep the design as simple as possible to reduce fencing and management costs and to allow larger paddocks, which facilitates optimal adaptive foraging. This rangeland management strategy is being increasingly taken up by ranchers in South Africa, Namibia and Botswana (Figure 4) with great success. Rotational grazing and HPG fall short of correctness on the four key concepts described above, whereas this split ranch grazing strategy is conceptually robust, supported by wildlife grazing strategies and is less complex and cheaper to implement and manage. Thus I expect this to be the future of grazing management. Courses and training on implementing such grazing strategies are available from a key pioneer of this grazing strategy, Riaan Dames:
(see http://www.bestfarmer.co.za/index.php?page=shop.product_details&category_id=8&flypage=flypage-ask.tpl&product_id=1&option=com_virtuemart&Itemid=1&vmcchk=1&Itemid=1).

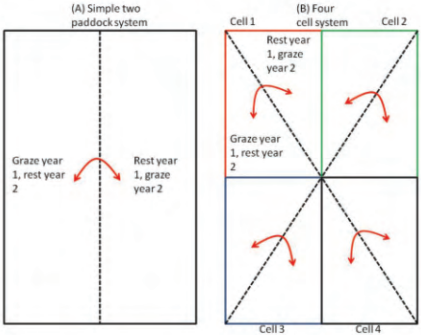

Figure 3: The split ranch grazing strategy can be run as a simple approach where the ranch is simply split into two halves (A) or a multi-cell approach (B) where each cell is split into two halves with a herd being contained and managed within that cell as a ranch within a ranch.

Figure 4: A contrast of a grazed and rested half of a cell at Tiisa Kalahari Ranch, Ghanzi.

The photo was taken in the early dry season (late May) just before the cattle are moved to the rested half. Note the dry-season reserve of forage available to the cattle on the rested half of the cell and the non-selective defoliation of all tufts and excellent trampling impact, which buries seed. Holistic planned grazing advocates the need to use large, bunched herds of cattle to create sufficient trampling and grazing impact but we have found that better and more uniform grazing and trampling impact is obtained by the split ranch approach, which focuses the cattle on half the ranch for a year (Photo credit, Kevin Grant).

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Native shrubs: a simple fix for drought-stricken crops in Sub-Saharan Africa

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Variability is the only guarantee when it comes to the rainfall of the Sahel, the transitional zone between the parched Sahara Desert and the wetter savanna in the south. The rains often arrive late, and sometimes they barely come at all. This can lead to devastating crop failures and famine in a region that relies heavily on the rain to grow most of its food. Over the centuries, farmers across the Sahel have adapted to the fickle rainfall by growing crops such as millet, sorghum, peanut, and cowpea, which are well suited to produce grain even during periods of drought stress. Sometimes, however, the crops' adaptation is not enough to protect them from extended droughts, and grain yields plummet due to lack of water.

To confound the already dire problem, the population of the Sahel is growing and crop yields are not increasing in step. In these nutrient-poor soils with low fertilizer input, the land is in desperate need of agriculture systems which can provide adequate yields and soil conservation with minimal inputs. This research on soil hydrology in the Sahel is part of a larger project investigating how traditional techniques practiced by some farmers can be adapted to further increase crop yields, even during times of drought stress. We found that planting food crops together with the native woody shrub Guiera senegalensis can improve crop growth with minimal costs. It is a simple method that can be used not only in the Sahel but may be applicable in many other areas that are periodically inhospitable to agriculture.

Drinking from the same straw

In other agroforestry systems where crops are grown in association with trees, the trees can outcompete the crops for water and reduce the growth and yield of the crops nearby. In our work, we investigated a process called hydraulic lift, also known as hydraulic redistribution, whereby the G. senegalensis shrubs pump water from deep in the soil, up through their root systems during the night and deposit it in the dry upper soil layers when they are not actively photosynthesizing. Hydraulic lift has been seen in environments that undergo periodic drought spells and has been shown to increase the ability of shallow roots to take up nutrients and maintain higher levels of transpiration and photosynthesis. Our hypothesis was that each day, nearby pearl millet crops take advantage of some of this

water which is drawn up by the shrubs. To test the hypothesis of water transfer, we set up a field study in Senegal under the harsh Sahelian conditions. This work is part of an ongoing research study looking at the growth of crops in association with the shrubs during the rainy cropping season. In order to create the necessary dry conditions, we used irrigation to manipulate the amount and timing of water delivered for this experiment. We monitored the soil moisture by using soil moisture sensors. , Our study was initiated once the daily drying and nightly re-wetting of the soil, characteristic to that of hydraulic, lift had been observed.

Water pathway

Hydraulic lift occurs when roots remove water from the upper soil layers during the day, causing the soil to dry out. Then with the wet soil deep down and dry soil near the surface, the water moves up through the plant along a gradient, just like sucking water through a straw. Once it gets to the upper soil layers, it is pulled into the dry soil surrounding the roots in the same way a dry sponge sucks up a spill on a countertop. Our hypothesis is that some of this water is released from the roots and is used by nearby millet plants. To carry out the experiment we attached bottles of water with a chemical tracer to the deep roots of the shrub. Then we collected aboveground samples of the shrub and crop stems growing nearby over a period of five days to see where the tracer water went. We found evidence of the tracer in a shrub on the first day after injecting the water, and shortly thereafter we found it in a crop growing nearby. This finding strongly supports the idea that water movs up through the roots of the shrub and into the crop. The exact route from the shrub roots to the crop is a topic of further investigation, but we are confident that a pathway exists. This combination of hydraulic lift and water transfer between species has long been hypothesized but rarely seen. It has never been observed as a component of an agroforestry system with such profound effects on crop production. Our team consisted of American and Senegalese professors and graduate students, researchers from multiple African countries, and local farmers hired as field technicians. We rented land from a farmer named Saliou Diouf who works closely with the researchers at the Senegalese Agricultural Research Institute. Saliou and his sons gave us invaluable perspective on cultivating millet and managing the shrubs. With the proceeds from research activities on his land, Saliou's family has been able to build a drip irrigation system and buy water from the communal well in the village to grow and maintain a thriving vegetable business.

Power of native plants

The amount of water transferred between plants appears to be quite small. However, the quantity of water deposited may be much less important than the location where it is released.

The small cylinder of soil which surrounds plant roots, called the rhizosphere, plays a crucial role in a plant's growth. It is the gateway through which most of the necessary water and nutrients must pass to nourish the plant. It harbours a high concentration of microbes which perform a wide variety of tasks. Therefore, maintaining the viability of the rhizosphere to perform its functions under water stress is extremely important, and this zone is precisely where hydraulic lift deposits water. In our tests, we observed the roots of the crops engulfing the shallow shrub roots and we speculate that may be related to the uptake of water.

G. senegalensis grows extensively throughout the Sahel. The management technique under investigation involves planting the shrubs at a density higher than their natural distribution on the landscape so that they can help promote crop growth in a number of ways. The ways in which hydraulic lift can affect the structure and function of the soil microbial community are also being investigated by our interdisciplinary team with the NSF Partnership for International Research and Education (PIRE) program. In other species hydraulic redistribution has been observed to significantly alter the function of the microbial communities as well. We are also looking at how the presence of the shrubs, along with their potentially higher rates of micro and mesofauna – small organisms which live in soil, can affect the structure and characteristics of the surrounding soil.

Why smart agricultural development is needed in Africa's Savannas

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Sub-Saharan Africa is the world's most rapidly growing region. By 2050, the continent's population will double and per capita GDP income will triple. This combination of people and prosperity means that Africa's food needs will quadruple. We estimate that satisfying this increased demand will require at least 140 million hectares of new farmland, even if crop yields grow at the high rates predicted by the Food and Agricultural Organisation.

Meeting these needs will be a great challenge, one that will be exacerbated by growing efforts to turn Africa into a source of food and fuel for the rest of the world. Investors are acquiring large areas to grow commodity crops for export or to produce biofuels that could help satisfy Europe's renewable fuel mandates. Some international institutions encourage this form of agricultural development. Underlying this international interest is the notion that Africa holds a large reserve of potential croplands that could be developed with low environmental cost. This is the vast 700 million hectare belt of savannas (a varying mixture of trees, grasses, and shrubs) that encircle Africa's equatorial rainforests, where annual rainfall is at least 640 mm. Several studies consider these savannas to be low cost areas for agricultural expansion, based simply on the fact that they are not forests. Fortunately, these savannas have decent farming potential. But that potential does not mean that farming them will have little environmental cost. Research tells a different story Our recent research shows that this assumption of low environmental cost is not valid.

We first compared potential maize and soybean yields in currently unfarmed African savannas with the carbon that will be lost when they are turned into croplands. The carbon lost per ton of crop grown measures the carbon efficiency of land, a metric that evaluates both the environmental costs and benefits of farming. We then calculated carbon efficiencies for all existing maize and soybean farmland in the world and asked a simple question: Would Africa's savannas be significantly (at least 1/3) more carbon efficient? We found that only 2-11% of Africa's savannas would qualify. We next asked, what is the potential to produce biofuels with low environmental costs? Biofuels reduce carbon released from burning oil, but turning savannas into cropland would release the carbon stored in vegetation and soils. EU biofuel standards require a net reduction of carbon emissions by half over 20 years. We found that only

around 1% of savannas could produce biofuels that meet these standards. We also found that Africa's wet savannas have nearly as many bird and mammal species as tropical forest regions. Converting these lands would therefore lead to substantial biodiversity loss. In short, converting Africa's wetter savannas will have high environmental costs, which is unsurprising if we look at savannas elsewhere, such as Cerrado and Gran Chaco, which together span four South American countries. These regions have recently undergone rapid agricultural transformation, resulting in large carbon and biodiversity losses. Lessons for Africa Does our research mean Africa should avoid all agricultural expansion? No. But our findings have two main messages.

1. African savannas should not be considered an environmentally cheap source of new land to satisfy overseas commodity or biofuel demands. The best areas for growing staple crops should be farmed to feed Africans.
2. New farmlands should be selected according to two criteria: that they produce the most amount of food for the lowest environmental and socio-economic cost. Our work also suggests that export agriculture should focus on high value cash crops that require less land. Although Africa imports much of its staple foods, it is already a significant exporter of high value crops. Looking ahead

If African countries adopt an approach that simultaneously considers the benefits and environmental costs of agriculture, they can mitigate many of its negative impacts. This would mean breaking from conventional development practice, but would make African countries leaders in sustainable agriculture. Can it be done?

Mostly, this will be a political choice. As a continent, Africa has a strong interest in protecting its savannas as well as its forests, because losing these areas could disrupt regional climates and other important environmental services. But each country will determine its own land use, and the degree to which such risk is avoided depends on how many nations adopt this more sustainable model in which new cropland is carefully selected and production on existing farmland is maximised. A regional pact to adopt this approach would help ensure that it prevails over the old expansionary model. From a technical perspective, this approach will also require fine-scaled analyses to identify the most suitable lands, considering a wider range of agricultural benefits and environmental and social costs. We are developing an example in Zambia. Doing such analyses will require much more accurate, granular data on land use practices than are currently available. Several projects are underway that will help, such as the Africa Soil Information Service, the Geo-Wiki and Mapping Africa projects, and new efforts to improve data access, but much work is still needed. We believe that African agriculture can follow this path. Other sectors of African economies have already defied

conventional development wisdom. One example is the explosive growth of cell phone usage, which has made landlines largely irrelevant and spurred the invention of world-leading services, including ones that will greatly improve farming practices. Such innovation demonstrates that African countries have the capacity to become global pioneers of smart agricultural development. The question is: do they have the will?

Movers and Shakers

Dave Ward
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I am now the Art and Margaret Herrick Endowed Professor of Plant Biology at Kent State University in Kent, Ohio, U.S.A. I'll be focusing on research on encroaching and invasive plant species in Ohio (there are about 2200 flowering plant species in Ohio of which as many as 800 are considered invasive!). I'll also be coming back to South Africa, hopefully on an annual basis, to continue my research with Adrian Shrader on the impacts of elephants on vegetation in Ithala Game Reserve, northern KwaZulu-Natal. Every 2nd year, I'll be running a field course for Kent State University undergraduates to Wits Rural Facility near Kruger Park and to the Cape Floral Kingdom (Cape Town and surrounds) during the(ir) winter break (January). I'll be teaching a course on "Invasion Biology" to undergraduates and a graduate course on the "Evolution of Life Histories" in addition to the field course just mentioned.