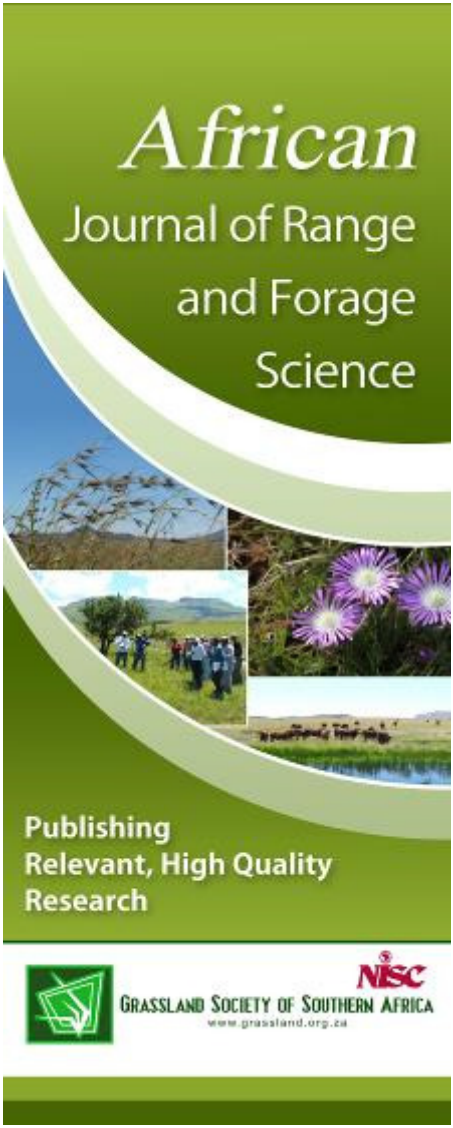

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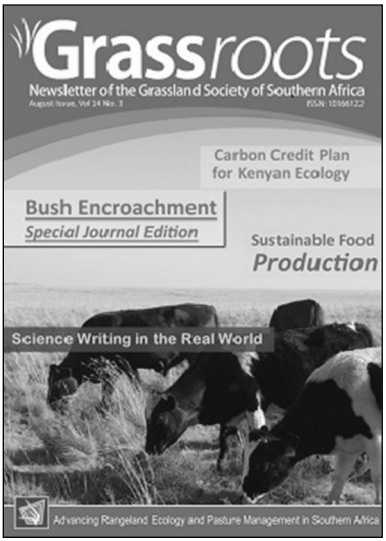

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Editor's Note

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This issue is also packed with news snippets relating to the fields of grassland science, and has a special focus on young grassland scientists. Reports on carbon credit plan aims to save Kenyan trees and elephants as well as the current status of South Africa's water resources are, amongst others, included in this issue.

The 49th Annual Congress of the GSSA was, as always, most successful. Congratulations to the Organizing Committee for a job well done!

Pieter Swanepoel

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Carbon Credit Plan Aims to Save Kenyan Trees and Elephants - and Help Villagers

Carmen Russell-Sluchansky
National Geographic

The three-week-old carcass in Kenya's East Tsavo National Park is hardly identifiable as an elephant anymore. Gone are the hallmark tusks and expressive trunk; the elephant's entire face has been hacked off.

The perpetrators used a machine gun, said Eric Sagwe, who leads a private antipoaching patrol in the park, pointing to bullet-scarred trees and the remains of two more elephants nearby."For 30 years, this elephant was taken care of," he said. "Then someone comes and kills it in just a few minutes. I'm very sad to see this." (Related: "Beloved African Elephant Killed for Ivory—'Monumental' Loss.") The words on Sagwe's uniform, Wildlife Works, are an abbreviation for Wildlife Works Carbon, Inc., a company based in the Kasigau area of southern Kenya, where hundreds of elephants still roam. Sagwe is one of the company's 140 "wildlife rangers." He hopes the ranger ranks will continue to grow, but that will depend on whether his employer can sell enough carbon credits on the international market to sustain the Kasigau Corridor Carbon Project, as it's known.

The concept of carbon emissions trading, involving carbon "credits" as an economic incentive, was laid out in the UN's Kyoto Protocol, an international treaty that came into force in 2005 to help mitigate climate change. Under the protocol, caps were placed on the greenhouse gas emissions industrialized countries were permitted to emit. Those that exceeded their limit, however, could buy "credits" from other member nations whose emissions fell below their target levels. The concept was extended to private companies (and even individuals), which could earn credits for reducing their carbon emissions by engaging in sustainable practices such as using solar power instead of coal or gas or protecting trees. Carbon emitters could buy those credits on a voluntary carbon exchange market to offset their own pollution.

Kasigau and Carbon Credits

Works's Kasigau project is the country's pilot carbon offset initiative. The Wildlife Works rangers monitor more than 500,000 acres of wooded land in the Kasigau Corridor—a stretch between Tsavo East and Tsavo West national parks containing more than 110,000 inhabitants—to prevent illegal tree-cutting and keep elephant poachers at bay. David Antonioli, head of the Verified Carbon Standard (VCS), the organization that sets rules and procedures and awards carbon credits, said those involved in the Kasigau project "are really pioneers. Not until this project came on

board did anyone have any good examples [to] point to and say, Here's how it works." Villagers hired by Wildlife Works count trees in the corridor, and the total amount of carbon stored in them is then calculated. Although the company self-reports this information, VCS carries out field audits (through another company, Environmental Services, Inc.) before issuing credits. Thus far, the project has been assessed as worth more than 1.2 million carbon credits, known as Verified Emission Reductions (VERs), each year over the past five. During that time Wildlife Works claims that deforestation has been reduced to nil. The company sells its carbon credits through the Markit Registry to corporate customers and banks, including Microsoft, Coca-Cola, Hershey's, Barclays, Allianz, and BNP. According to Wildlife Works VP, Rob Dodson, the total annual revenue from these transactions has ranged between $3.5 million and $7 million. In addition to the rangers, Wild Works's nearly 400 employees include horticulturalists, carpenters, seamstresses, mechanics, and teachers. A third of the carbon credit revenue goes to staff salaries and other operating costs. Another third goes to community landowners to compensate them for not exploiting Kisagau's natural resources for profit.

Community Benefits

The final third is split between investors and so-called carbon committees to be used for projects that benefit area communities. The committees determine what projects to undertake, prioritizing them by need and feasibility. "So many people have problems with water, so water projects—water tanks, water pipelines—always come first," said Paschal Kizaka, a local chief and committee board member. "Now people do not have to walk for miles to carry drinking water back to their homes. Education is another major focus. More than 2,500 students have received carbon-funded scholarships for secondary and university schooling, and some communities have used their funds to build schools and equip classrooms with desks and learning materials. "The children were learning outside," said Ngare Duncan, who heads one committee. "And some children had to walk to school over eight kilometers that was infested by wildlife." Some money is used for training women to make eco-responsible household materials, such as natural soap.

Can the Project Be Replicated?

"The real value of [Kisagau] is it shows what can be done to fight climate change and eradicate poverty, as well as stop poaching," said Tim Christopherson of the United Nations Environment Programme, noting that the factors here were "just right" for success. "[Wildlife Works] has been in that area for years, so they know the local community, and they trust each other." Because Kisagau is a dry region that lacks the natural abundance of, for instance, the Congolese or Amazon rain forests, where people tap the resource base for profit, most village communities have opted in. Perhaps the biggest challenge to Wildlife Works's profitability—and, for that matter, its very survival—is the future of the voluntary carbon market. With the expiration in 2012 of key provisions of the Kyoto Protocol, and the inability of national governments to come to

an agreement on acceptable levels for greenhouse gas emissions, demand for carbon credits has fallen.

And, Christopherson pointed out, despite Kasigau's worthy accomplishments, the project is a small-scale effort at limiting greenhouse gases—"peanuts," as he put it. "We need to figure this out on a global level," he said. "There's a limit to how much we can use exchanges to offset emissions. If industrial emissions aren't capped, it doesn't matter if you were to protect even all of the Amazon."

"Works's Kasigau project is the country's pilot carbon offset initiative"

CSIR completes vital report on South Africa's water sources

Press Release

South Africa's investments in the construction and maintenance of engineered water infrastructure will be undermined in the long run if we do not protect the limited ecological infrastructure that provides us water. This is the caution from the recently released report titled 'Defining South Africa's water source areas', which maps South Africa's key water sources.The study was conducted by scientists from the CSIR in collaboration with the Global Environmental Facility (GEF) and the Worldwide Fund for Nature (WWF). It found that only 8% of South Africa's land area supplies a staggering 50% of the river run-off, which supplies major dams and drives economic activity in the country.

Dr Jeanne Nel – the main author of the report and a CSIR principal researcher in biodiversity and ecosystems – describes this finding as an important wake-up call for South Africa to prioritise water security in the country. "This report is part of our commitment as the CSIR to develop research solutions to improve water quality and quantity, and promote water security for our water-scarce country. By managing this tiny fraction of our land well, we can greatly improve our chances of building a secure water future," Nel remarks. Launched in Cape Town by Mohammed Valli Moosa – the former minister of Environmental Affairs and Tourism and current director at Sanlam Limited – the report outlines the importance of these areas as sources of water in South Africa. It provides an assessment of key land uses in each of the source areas to use as a foundation towards developing strategies for sustainable land use practices.

The report highlights the availability of fresh water as one of the major limiting factors to South Africa's development. It calls for urgent action to protect the ecosystems that support healthy water resources, eliminate water wastage and ensure usage of water in the most efficient and effective ways possible. South Africa's water's sources are inconveniently located away from the centres of major industry, and tied to seasonal cycles. Deterioration of water quality and quantity in these areas can have a disproportionately large negative effect on the functioning of downstream ecosystems and the overall sustainability of growth and development needs of the country. "The importance of managing this small fraction of land that contributes so vitally to our water security should not only be acknowledged, but prioritised at the highest levels across all sectors. Currently, only 16% of our water source areas are formally protected and we should move fast to ensure that this percentage is significantly increased through management agreements with private land owners," says Nel.

"The maps released in the report were based on systematic and expertly reviewed scientific data collected over decades from rainfall and flow gauges across the country," says Janis Smith, CSIR researcher and co-author of the report. "The catchment areas we identified though these data are the key drivers of economic development as they supply water to the majority of the country, including economic hubs, farms and industrial facilities. We need to act now to ensure that the right measures are in place to protect them. We need to focus on our water source areas if we are to create a legacy for water security," continues Smith.

Other key issues highlighted in the report include the risk posed by coal mining in the Ekangala and Mpumalanga Drakensberg source areas and the success story of the headwaters that feed the Berg River Dam. "The Berg River Dam's success proves that deliberate efforts in managing and protecting key catchment areas can achieve positive results for downstream users. This area, previously covered in alien invasive vegetation, has been cleared and natural fynbos has been restored. The landscape is now more resilient to fires, floods and drought and delivers good quality water to the dam," concludes Nel.

Ecological restoration at Sendelingsdrif

Cracking the habitat code of the critically endangered *Juttadinteria albata* succulent

Lineekela Nauyoma

The snow white flowers in the Sendelingsdrif area, *Juttadinteria albata*, are very rare and occur exclusively in a small area centered on Namdeb's new Sendelingsdrif mine. So small and vulnerable is the population of this species that it has been accorded the highest 'Critically Endangered' conservation status in the red data book of the International Union for Conservation of Nature (IUCN), a status paralleled by species such as the black rhino. Namdeb's mining operations at Sendelingsdrif will inevitably strip away areas of *Juttadinteria albata* habitat in the on-going search for diamonds.

Following mine closure the mining areas will be restored to allow plants and animals to thrive again but recreating the habitat for *Juttadinteria albata* will not be easy.

Although it is able to germinate in a greenhouse, it seems that *Juttadinteria albata* has very specific growth requirements in nature, which may be the reason for its small distribution range.

To assist with the successful restoration of the *Juttadinteria albata* population at Sendelingsdrif, an experiment was initiated in January 2013 on site by Namdeb. This initiative is supported by the University of Namibia and Gobabeb Research and Training Centre. This so called 'heap' experiment consists of twelve heaps (5m in diameter) spaced about 15m apart. It is made up of a mixture of waste materials that will be similar to the materials eventually used for back-filling mined areas.

The main objective of this experiment is to understand which slope angle, aspect and amount of rockiness Juttadinteria albata prefers in order to recreate its habitat during restoration and in addition to choosing spots best for transplantation or the sowing of seeds.

To see the beautiful white flowers of *Juttadinteria albata* where once there were excavations, will be a great victory for responsible mining.

"Following mine closure, the mining areas will be restored to allow plants and animals to thrive again but recreating the habitat for *Juttadinteria albata* will not be easy."

The participants in the restoration ecology heap experiment. From left to right: Joyce Katjrua, Liezl Maritz, Elizabeth Nakathingo, Alfues Shekunyenge (MSc student, University of Namibia), Sivanus Kaulwa, Hireeka Nauyoma (MSc student, University of Namibia), Cherilee Fortuin, Ursula Witbooi and Ferdinand Mwapopi. Absent: Dr Cornelis van der Waal (Gobabeb Research and Training Centre)

The EWT Launches a Roadkill Mitigation Project in the Pilanesberg National Park

Press release
wendyc@ewt.org.za

The Endangered Wildlife Trust's Wildlife and Transport Programme (EWT-WTP) has launched a new project which aims to reduce animals killed on roads in National Parks. Pilanesberg National Park in North West Province is the first South African park to support the initiative. Pilanesberg is the third most frequented park by international and national visitors alike, and is managed by North West Parks and Tourism Board. The Park is unique in that it occurs within the transition zone between the dry Kalahari and wetter Lowveld vegetation, commonly referred to as "Bushveld". Thus it has a rich diversity of birds, mammals and plant species.

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"During last week's surveys in the Pilanesberg I found 23 dead animals on the road including terrapins, snakes and rodents. There were also a number of frogs and birds, which were unfortunately too squashed to identify accurately to species level. From work already conducted, we know that roadkill peaks between January and April in South Africa when migratory birds are present, and reptiles, amphibians and mammals are more active. I was not expecting to find as many casualties of roads as I did in the month of May," said Collinson. "We also conducted approximately 234 questionnaire surveys during our May visit, 181 of which were visitors from South Africa, with the remaining 23 from overseas. Twenty-seven respondents declined to participate in the survey. Of the surveys, 141 said that they had noticed roadkill outside of protected areas, whilst only 19 said that they had seen roadkill in national parks. These included tortoise, birds, snakes, and even a rhino."

Interestingly, when asked to define what roadkill is, many people considered roadkill to only be wildlife and not livestock. Fifty-four people did however mention invertebrates such as moths, butterflies, and dung beetles, and said that these were also at risk from vehicles. 141 respondents further said that they had experienced roadkill first hand, whilst 66 said that they had never hit an animal on the road. However, further questioning revealed that many people did not consider smaller species such as frogs and rodents to be a roadkill, possibly because they did not cause damage to the vehicle or are too small to be noticed on the road. This highlights a likely under-reporting of data being submitted by the public, and more public awareness is needed to highlight that ALL species have the potential to be affected by vehicles on roads. The EWT-WTP has started analysing the questionnaires in detail and will be able to provide further details once this process is complete.

"Some of the less obvious impacts of roads is that they often fragment habitat, which restricts animal movement and increases the isolation of populations. In addition to altering animal behaviour, some animals are attracted to roads. For example, snakes and other ectotherms habitually bask on tar roads, and some birds consume spilt grain from roadside vegetation. Similarly, antelope and other browsing herbivores are attracted to the dense vegetation or so called 'green curtain' of roadside edges. This attraction often exposes them to increased risk of being killed by vehicles. Some species avoid roads altogether and may shift home ranges, feeding sites and nesting areas away from the roads," continued Collinson.

The EWT-WPT will be back in Pilanesberg in October 2014 to conduct more roadkill data collection and questionnaires. Visitors to parks are encouraged to become citizen scientists by contributing to the research. If, during your travels, you spot any roadkill on our roads please record your sighting via our cell phone app, Road Watch South Africa, and the EWT-WTP will use the data you share in their work to reduce the impacts of transport on our wildlife. The app has been designed to simplify data collection. Just with a click of a button you will send us a photo of the incident, as well as the date time and GPS co-ordinates. To take part simply type this link into the Safari browser on your Android platform phone:http://www.prismsw.comroadwatch/androidRoadWatchSouthAfrica.apk. The app is also available Apple – simply search for Road Watch.

Thanks to Pilanesberg National Park, Copenhagen Zoo and Bridgestone South Africa for supporting the initiative. Thanks too to the citizen science volunteer network and Africa:Live, iSpot, Pilanesberg Honorary Officers and Makanyane Volunteers. For further information please contact Wendy Collinson on wendyc@ewt.org.za or Claire Patterson-Abrolat on clairep@ewt.org.za

Dead or Alive? Comparing Costs and Benefits of Lethal and Non-lethal Human–Wildlife Conflict Mitigation on Livestock Farms:

Jeannine S. Mc Manus[1], A.J. Dickman[2], D. Gaynor[3], B. H. Smuts[4] AND D.W. Macdonald[2]

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Abstract: Livestock depredation has implications for conservation and agronomy; it can be costly for farmers and can prompt retaliatory killing of carnivores. Lethal control measures are readily available and are reportedly perceived to be cheaper, more practical and more effective than nonlethal methods. However, the costs and efficacy of lethal vs non-lethal approaches have rarely been compared formally. We conducted a 3-year study on 11 South African livestock farms, examining costs and benefits of lethal and non-lethal conflict mitigation methods. Farmers used existing lethal control in the first year and switched to guardian animals (dogs *Canis familiaris* and alpacas *Lama pacos*) or livestock protection collars for the following 2 years. During the first year the mean cost of livestock protection was USD 3.30 per head of stock and the mean cost of depredation was USD 20.11 per head of stock. In the first year of non-lethal control the combined implementation and running costs were similar to those of lethal control (USD 3.08 per head). However, the mean cost of depredation decreased by 69.3%, to USD 6.52 per head. In the second year of non-lethal control the running costs (USD 0.43 per head) were significantly lower than in previous years and depredation costs decreased further, to USD 5.49 per head. Our results suggest that non-lethal methods of human–wildlife conflict mitigation can reduce depredation and can be economically advantageous compared to lethal methods of predator control.

The full article is available at http://journals.cambridge.org and could be cited as: Mc Manus, J. S., Dickman, A. J., Gaynor, D., Smuts, B. H., & Macdonald, D. W. (2014). Dead or alive? Comparing costs and benefits of lethal and non-lethal human–wildlife conflict mitigation on livestock farms. Oryx, 1-9.

Tropical Grassy Ecosystems Under Threat, Scientists Warn

Catherine L. Parr, Caroline E.R. Lehmann, William J. Bond, William A. Hoffmann, Alan N. Andersen.
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Scientists at the University of Liverpool have found that tropical grassy areas, which play a critical role in the world's ecology, are under threat as a result of ineffective management. According to research, published in *Trends in Ecology and Evolution*, they are often misclassified and this leads to degradation of the land which has a detrimental effect on the plants and animals that are indigenous to these areas.

Tropical grassy areas cover a greater area than tropical rain forests, support about one fifth of the world's population and are critically important to global carbon and energy cycles, and yet do not attract the interest levels that tropical rainforests do. They are characterised by a continuous grass understorey, widespread shade-intolerant plants and the prevalence of fire, which all generate a unique and complex set of ecological processes and interactions not found in other habitats. Dr Kate Parr, from the School of Environmental Sciences, said: "The distinctive evolutionary histories and biodiversity values of these areas needs to be recognised by conservation managers and policy makers. "Whilst it is generally assumed that 'more trees are better' in tropical rainforest this is not necessarily the case for tropical grassy ecosystems and so the outcomes of global carbon and conservation initiatives, which include the UN's Clean Development Mechanism and its Reducing Emissions and Deforestation Forest Degradation schemes, need to be better considered when they are applied to tropical grasslands. "Any changes to the balance between human livelihoods and ecosystem function would have an impact on the use of land, the availability of resources and would affect the way the land functions including its climate. "The vast extent of tropical grasslands and the reliance of human welfare on them means that they deserve far more research and conservation attention than they currently receive."

Approximately 20% of the world's population depend on these areas of land for their livelihoods including their use for grazing, fuel and food. They also store about 15% of the world's carbon. Tropical grassy ecosystems are associated with savannas and upland grasslands in Africa and savanna-type grasslands in India, Australia, and South America, representing diverse lands from open grassland through to densely canopied savanna.

Rare Honour for SAEON Scientist

Press Release

SAEON's Chief Research Scientist, Prof. William Bond, has been elected a foreign associate of the United States' National Academy of Sciences, an honour conferred on the world's best scientists by their peers.

The National Academy of Sciences is an independent, non-profit society, established by an Act of the United States Congress in 1863. It is regarded as one of the top academies in the world. Its task is to provide independent, objective advice to the US government on matters related to science, engineering and medicine. Nearly 500 of its 2 214 members and 444 foreign associates have won Nobel Prizes. Foreign associates are non-voting members. Only 21 foreign associates are elected annually, based on an extensive vetting process that results in a final ballot at the academy's annual meeting in April every year.

Highly cited researcher

In addition, William has just been notified that he has been selected as a Thomson Reuters Highly Cited Researcher, one of only six South African scientists to receive this accolade. As a member of the Highly Cited Researcher list, he is also included in the "2014 The World's Most Influential Scientific Minds."

Top-rated scientist

William Bond is one of South Africa's top scientists. He is an ecologist with broad interests in the processes most strongly influencing vegetation change in the past and present, including fire, vertebrate herbivory, atmospheric CO2 and climate change. In addition, he has worked on plant-animal mutualisms and on plant form and function. Particular research interests include grasslands and savanna ecosystems, and winter-rainfall shrublands.

William has served on the Boards of the South African National Botanical Institute and Cape Nature, and on the editorial boards of several journals. Among his achievements he authored and co-authoring nearly 200 papers and three books. Describing these latest achievements, William said he was "very pleasantly surprised. It is easy to think you are on the fringes on things in Africa. Recognition by the National Academy of Sciences is an extraordinary affirmation of the relevance of ecological studies in Africa to the wider world of science." The CEO of the National Research Foundation, Dr Albert van Jaarsveld, joined SAEON and the South African research community in congratulating William: "It is a tremendous honour for any South African scientist to be elected a foreign associate of the US National Academy of Sciences," he said.

"I would like to congratulate Professor Bond on this extraordinary and well-deserved achievement. William has been an inspiration to many young ecologists, especially here at home for many years. It is therefore particularly gratifying to see his contributions also being recognised by our international peers.

"As an NRF A-rated scientist, William recently joined the South African Environmental Observation Network (SAEON) as its Chief Scientist. We expect that his inspirational career and leadership will enthuse young scientist working on the SAEON platform to emulate his achievements over the coming years."

William on stage during the signing ceremony of the United States' National Academy of Sciences, of which he has been elected a foreign associate

William is passionate about passing his knowledge on to the next generation of scientists

The Camp that Trains Would-be Scientists

Joe Sibiya
Education Outreach Officer
SAEON Ndlovu Node

The SAEON Ndlovu Node's annual science camp for learners is the flagship initiative in the node's science education programme. Each year the camp provides an opportunity for specially selected grade 9-11 learners from local high schools in the Phalaborwa region to participate in the environmental science education learning experience. Learners on the camp are exposed to scientists who engage them in intensive structured, small-scale research projects aimed at stimulating their scientific knowledge and skills and promoting teamwork. In addition, learners are introduced to diverse careers in environmental sciences and afforded the opportunity to complete career portfolios with the objective of guiding them in setting career goals for themselves, as well as identifying their abilities and career interests. A group of 14 learners participated in the fourth grade-10 science camp held at Silver Mist Resort at Haenertsburg in the Limpopo Province in April 2014. The theme for the camp, "Biodiversity - comparison and contrast", served as inspiration for the learners as well as for participating scientists. The overall objectives of the camp were to strengthen the learners' scientific thinking by encouraging and enabling them to develop and complete their own scientific projects, and to evaluate personal skills and goals in the light of future career choices.

Sampling the habitats

Early the next morning staff members Sharon Thompson and Thobile Dlamini (Grassland), Dr Dave Thompson and Thabo Mohlala (Forest), and Thembi Marshall and Joe Sibiya (Plantations) led the teams to the study sites to begin the hard work of sampling the habitats. Each team diligently collected data at the respective sites. They were also expected to determine the different life forms occurring within the respective habitats.

Analysing the data

Later that afternoon it was time for the would-be scientists to start analysing their data and preparing posters for presentation the next day. It was inspiring to witness grade 10 learners taking control of their learning. The teams showed some insight into, and understanding of scientific methods by applying scientific method procedures in their research projects.

Presenting the research findings

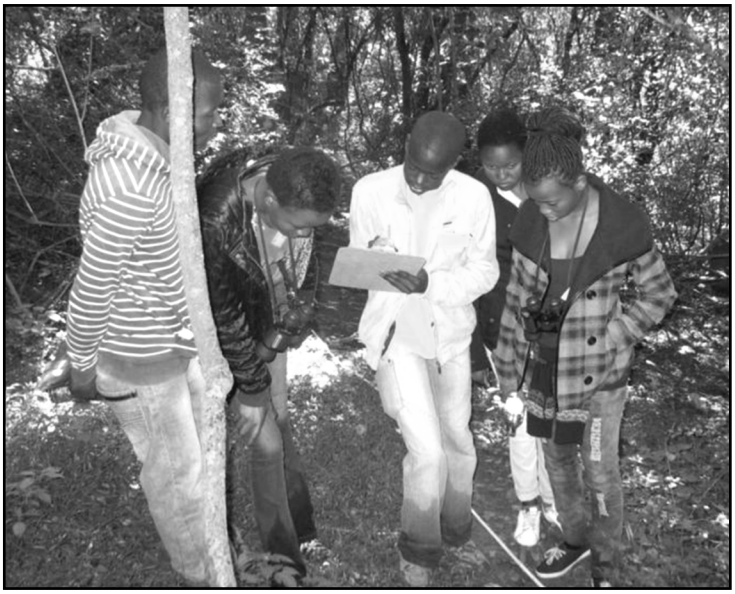
On the final day, the teams presented their research findings. The research results of the Grassland team showed that while no trees occurred in this habitat, there was a multitude of other species like birds, insects and forbs other than grass.

This was contrary to the early observation that only grass occurred in the grassland habitat. The results of the Plantation team showed that plantations are unnatural, consisting of the same type of tree species planted in rows. The results were consistent with the early observation made that trees in plantations were evenly distributed. The team found other life forms like moss and invertebrates in the plantation.The Forest team's research results indicated a mix of grass and forbs, and a combination of tall and short trees in this habitat. They also found different types of insects and birds in the forest.

The presentations culminated in a lively debate based on the research findings as to which habitat was more important. The Grassland team argued that their habitat was more important than the others because it provides grazing for cattle and offers a home to terrestrial insects and birds. The Forest team defended their habitat by saying it promoted biodiversity. The Plantation team presented their case that this habitat was more important based on its economic value. Finally, a consensus was reached that all the habitats were important and that all of them needed to be conserved.

The intrepid Grassland team tackle their project with gusto (Picture: Sharon Thompson)

Grassland team members search for invertebrates occupying this habitat (Picture: Sharon Thompson)



Members of the Forest team collect data using a quadrant at each 15 m on a 30-m transect (Picture: Dave Thompson)

Sustainable Food Production: Facts and Figures

Zareen Bharucha*
*http://www.scidev.net/global/food-security/feature/sustainable-food-production-facts-and-figures.html

Farming must feed more people more sustainably. Zareen Bharucha looks at scientific approaches past and present.

Advances in agricultural science and technology (S&T) have contributed to remarkable increases in food production since the mid-twentieth century. Global agriculture has grown 2.5–3 times over the last 50 years. [1] This has let food production keep pace with human population growth so that, overall, there are enough calories produced per capita. However, progress toward reducing hunger is variable across the world. Hunger and malnutrition affect every aspect of human development and persist for various reasons including unequal access to land, to sufficient and nutritious food, and to other productive resources.

Adequate food production is necessary but insufficient to ensure national nutritional security. In India, for example, millions of households suffer from chronic undernourishment and malnutrition despite the fact that favourable years produce more than enough grain, and there is a public distribution system designed to supply poor households with subsidised grain. [3] Agricultural production needs to increase to address this unequal access to food and resources, and to meet the needs of a growing world population. It may need to increase by an estimated 70 per cent globally and by 100 per cent in developing countries by 2050 in order to keep pace with population growth and shifting diets. Reformed agri-food systems will also need to navigate complex resource limits imposed, in part, by environmental degradation to which modern agriculture has contributed. So the challenge for agriculture is three-fold: to increase agricultural production, especially of nutrient-rich foods, to do so in ways which reduce inequality, and to reverse and prevent resource degradation. S&T can play a vital role in meeting these challenges — for example, by developing innovations that smallholders with limited resources can afford and use.

Land and water pressures

About 12 per cent (1.6 billion hectares) of the world's land area is used for agriculture. Land degradation, or the loss of land's productive capacity, is a global problem (figure 2), but especially in dryland regions, a quarter of which are devoted to agriculture. [4] Drylands also support over 30 per cent of the world's population. [5]

Figure 1. 2012 Global Hunger Index scores [2] Source: von Grebmer et al.

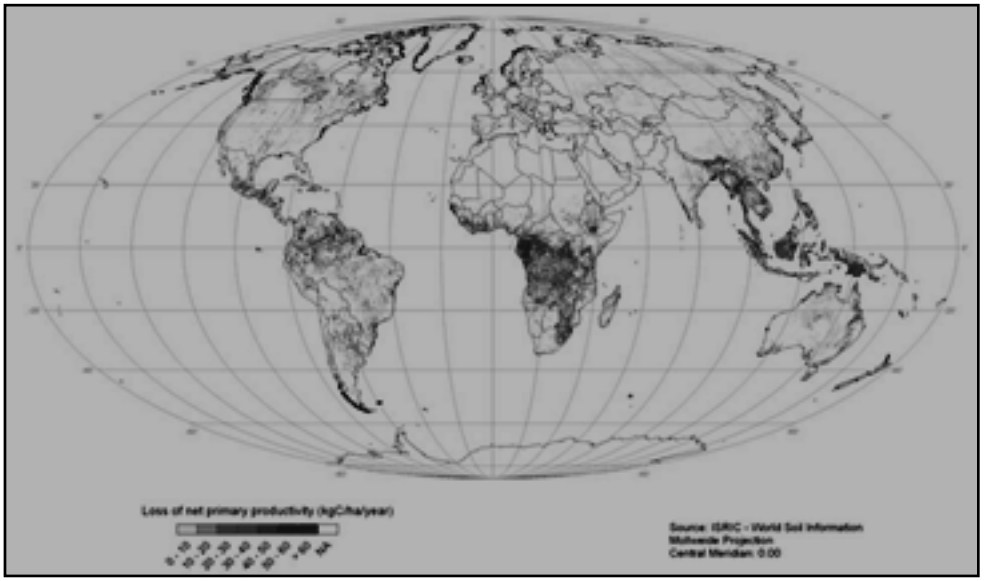


Figure 2. Global loss of Net Primary Productivity in degrading areas, 1981–2003 Copyright: ISRIC

Water management is another major challenge. Agriculture accounts for 70 per cent of all water taken from aquifers, streams, rivers and lakes. [1] To meet projected demands, the efficiency of water use (crop produced 'per drop') will need to improve in both irrigated and rainfed zones. Forty per cent of global increases in food production have come from irrigated areas. By 2050, the area under irrigation is projected to increase by six per cent over 2009 levels, and agricultural water withdrawals will need to increase by ten per cent over current levels. [1]

Rainfed systems are the world's largest agricultural system, taking up 80 per cent of cultivated land area and producing 60 per cent of the world's crops. In Africa, rainfed agriculture produces 97 per cent of staples. [1] Rainfed zones overlap with regions where risks of land degradation are highest, and where smallholder farming predominates. Yet, these are the very regions which will need to play a bigger role in providing food in the future — because the world's capacity to expand irrigation is limited, and the damage caused by over-irrigation and large-scale irrigation projects (such as land degradation and habitat loss) is now widely recognised.

Soil health

Crop productivity is also constrained by land management practices that lead to erosion, waterlogging and salinization (salt build-up), and loss of nutrients from soils.

Overgrazing, over-irrigation, using too much or too little inorganic fertilizer, ploughing and other mechanical disturbance all contribute to poor soils. Soil degradation is a particular problem in tropical developing countries, where soil is often less 'forgiving' of poor management. Across Africa, for example, agriculture that removes soil nutrients such as nitrogen, potassium and phosphorus without replenishing them (sometimes termed nutrient mining) contributes to low crop productivity. Phosphorus availability is a key concern. Phosphorus is essential for plant growth and, unlike nitrogen fertilizers, cannot be produced artificially. Phosphorus is mined from finite deposits that are expected to be depleted in 70-125 years. [7] Strategies for dealing with this include managing soil phosphorus by judiciously applying inorganic fertiliser, preventing soil erosion, recycling nutrient-rich biodegradable waste (a traditional source of soil nutrients across much of the developing world) and crop improvements which modify plant roots to enable them to better absorb available soil phosphorus.

Energy and climate change

Another key constraint is energy availability, specifically of fossil fuels. Modern agriculture is energy intensive - tractor and transport fuel, producing agrichemicals and storing and processing food all depend on affordable fossil fuels. So there are growing concerns about the carbon footprint of the agrifood sector. Agriculture contributes around 13.5 per cent of global greenhouse gas emissions

Region	Yield gap* (%) in 2005
East Asia	11
Southeast Asia	32
Northern America	33
Western and Central Europe	36
Australia and New Zealand	40
Western Asia	49
Southern America	52
South Asia	55
Pacific Islands	57
Northern Africa	60
Eastern Europe and Russian Federation	63
Central Asia	64
Central America and Caribbean	65
Sub-Saharan Africa	76

*The difference between optimal and actual yield affected by real-life conditions and challenges such as environmental degradation or poor management.

Table 1: Yield gaps for cereals, roots and tubers, pulses, sugar crops, oil crops and vegetables in 2005 [1]

as a result of cultivation practices and the expansion of agricultural land into forest areas, releasing stored carbon from above and below ground. And there are complex, context-specific impacts associated with climate change. Delayed or early onset of seasons, more variable precipitation and temperatures, and increasing incidence of climate 'shocks' — such as unpredictable dry spells — can all affect plant growth. To adapt to these changes farmers will need knowledge, financial and social support and a package of context-specific technologies (some old, some new).

Fundamental transformation

These challenges and constraints call for a fundamental transformation in agriculture across the world. Increasing food production could follow either *extensification (*converting forests, grasslands and other 'natural' ecosystems into cropland) or *intensification (*increasing the amount produced per hectare within existing cropland). Intensification is generally preferred as it spares other ecosystems from agricultural use.

To meet food demands, intensified agriculture will need to close so-called 'yield gaps' — the difference between current yields and those obtainable under optimal management — in ways that prevent, or in some cases reverse, environmental harm. Table 1 shows global yield gaps for key agricultural commodities.

A brief history of agricultural S&T

Farming depends on experimentation, observation, and carefully designed resource management systems. Mexican farmers' domestication of wild teosinte (maize's ancestor) 9,000 years ago provides one of the best-known examples of ancient crop-breeding. Careful husbandry of plant and animal biodiversity has been practised since antiquity in home gardens and through the domestication of edible species. [8] Soil and water management also has a long history. Careful husbandry of plant and animal biodiversity has been practised since antiquity in home gardens and through the domestication of edible species. [8] Soil and water management also has a long history.

In modern times, S&T have made key contributions through advances in plant breeding (notably improved varieties of maize, rice and wheat), by developing synthetic pesticides and fertilisers and by mechanising farming practices along the production chain from 'field to fork'. Applied in Asia and Latin America, these innovations contributed to substantial increases in food production in the early- to mid-twentieth century.

Beginning with new high-yielding wheat varieties developed in Mexico, the 'Green Revolution' raised global yields of wheat (208 per cent), paddy rice (109 per cent), maize (157 per cent), potato (78 per cent) and cassava (36 per cent) between 1960 and 2000. [10]

The science that made these increases possible was supported, in large part, by an enabling policy and funding environment (see figure 3) and a focus on preventing hunger in the developing world. [11] The S&T supporting the Green Revolution stemmed from developments in biology and chemistry in the 1800s and early 1900s. Advances in plant breeding were based on Mendellian genetics. In chemistry, the Haber-Bosch process (developed by the German chemist Fritz Haber) converted atmospheric nitrogen to ammonia fertiliser on an industrial scale. The improved seeds and fertilisers these developments brought were supported by irrigation infrastructure and machinery, expert advice and credit.

Long-term impacts

The Green Revolution potently demonstrated S&T's potential to increase food production. It was lauded for averting catastrophic famine in the developing world, and also for 'sparing' non-agricultural land from conversion to cropland.

GM controversy

There is controversy over whether GM can increase crop yields while conserving resources.

1943	Office of Special Studies (OSS) established in collaboration between the Rockefeller Foundation and the government of Mexico, to begin work on improving agriculture for food security.
1944	US agronomist Norman Borlaug joins the OSS and begins work on breeding wheat varieties resistant to stem rust.
1946 onwards	US plant breeders at the ARS-Washington State University engage in hybridisation programmes to develop wheat varieties. The research team shares germplasm with Borlaug.
1950s	Borlaug develops Dwarf Wheat varieties by crossing germplasm from Japanese semi-dwarf wheat varieties with the best Mexican wheat varieties. These varieties help Mexico to become self-sufficient in wheat.
1960s	The International Rice Research Institute (IRRI) is founded in Manila, the Philippines, in order to develop improved rice varieties.
1963 onwards	Bourlag travels to India at the invitation of M. S. Swaminathan, the Indian Minister for Agriculture. India imports improved wheat seeds for testing. The Indian government rolls out a programme to cultivate improved varieties, supported by irrigation development and inorganic inputs.
1970 onwards	Yields of wheat in India and Pakistan begin to improve substantially due to Borlaug's improved varieties, inorganic inputs and increased irrigation. As a result, India becomes self-sufficient in wheat. Cereal production in Asia doubles between 1970 and 1990, outpacing population growth.

GM crops in commercial cultivation mainly express two traits — herbicide tolerance and pest resistance. These traits promise higher yields with lower pesticide use. However, their impacts have been variable and depend on a range of external factors. For example, India, China and South Africa found that socioeconomic, agronomic and institutional factors have had a big impact on farmers' experiences with Bt cotton technology. [14] In Africa, an analysis of 11 improved varieties showed that success depended not only on new technologies, but also on partnerships between researchers and local farmers at every stage of the innovation process. [15]

However, it is now clear that this early input-intensive model carries unacceptable long-term environmental impacts, for example unsustainable demands on aquifers for irrigation and damage to aquatic ecosystems.

These input-intensive practices were catalysed, in part, by inappropriate incentives and subsidies — highlighting the importance of governance for new technologies. Where these incentives were removed, agricultural practice changed accordingly. For example, insecticide use fell after Indonesia dropped pesticide subsidies in the 1990s. [12]

There were social concerns, too. Farmers with plenty of land, irrigation and credit benefited the most, while resource-constrained farmers, smallholders, or those farming marginal land benefitted largely indirectly — as a result of lower food costs and an increase in farm employment in favourable areas. There were also unintended nutritional outcomes of the Green Revolution. For example, intensive cultivation of high-yielding staples led to less dietary diversity and may have affected the availability and use of nutrient-dense 'wild' foods. [12]

New developments in agricultural S&T

Since the 1990s, a second 'wave' of technology development has sought new crop varieties through biotechnology, with controversy focusing on genetically modified (GM) crops. Some say GM crops are now "being taken up faster than any other agricultural technology since the plough 8,000 years ago, and are presently being used by 16 million farmers". [13] S&T advances have been based on molecular genetics, specifically recombinant DNA technology. This lets scientists combine genetic material from multiple sources (e.g. from two different species), creating combinations not otherwise found in nature. The first GM crop to be released for commercial cultivation was 'Roundup Ready' soybean in 1996, which resists the herbicide glyphosate, allowing farmers to apply the herbicide without harming soy crops. Since then, recombinant DNA has been used to develop 'golden rice' (a variety fortified with the vitamin-A precursor beta-carotene) and crops resistant to herbicides, insects and viruses.

Unlike the Green Revolution, which was funded and supported by public-sector bodies, the 'gene revolution' is primarily driven by a private and global research system where new technologies find their way to developing countries through the market. [10] There is tremendous private sector funding support for transgenic crops. As of 2005, for example, the top ten multinational bioscience corporations collectively spent nearly US$3billion per year on agricultural R&D — ten times more than that spent annually by the 15 CGIAR research centres, which together constitute the largest international public sector consortium supplier of agricultural technologies. [10]

Better varieties for smallholders

Smallholders deliver most of the food produced in developing nations, and their need for more productive, pest-tolerant and nutritious varieties is increasingly recognised. Several initiatives are seeking to develop and disseminate improved varieties of indigenous or traditional crops that have so far been neglected by privately funded biotechnology research.

For example, the African Orphan Crop Consortium (AOCC) aims to map and analyse the genomes of 100 so-called 'orphan' crops, selected by African scientists, which have so far been neglected as they were not economically important on the global market. The AOCC plans to make its data and findings freely accessible to researchers and breeders in Africa and elsewhere.

Case study of Quncho cereal in Ethiopia [16]

Tef (Eragrostis tef) is the main cereal grown in Ethiopia and vital for food security there. It is resilient to drought, waterlogging, diseases and pests. Research on improving tef varieties began in the 1950s, but had limited success due to the lack of funding and research. However, a new hybrid tef variety called Quncho was released by the Debre Zeit Agricultural Research Centre in 2006 and is proving popular with farmers.

Farmers participated in Quncho's development, helping select and breed the variety. Their involvement meant breeders developed a variety which closely matched farmers' and consumers' preferences. *Quncho* was also disseminated using an innovative approach. Instead of relying on conventional 'technology transfer', farmers were introduced to the new variety and its cultivation techniques through farmer-led testing, coordinated between research centres, administrative bodies, farmers and farmers groups, seed-growers associations, private seed growers and agro-processors. Farmers who adopted the variety were supported with seed loans, training, regular follow-up and assistance from researchers and staff from local development agencies. The number of farmers receiving training on tef production increased from 360 to 6,250 from 2006 to 2009. Farmers have saved and distributed seeds amongst themselves in a well-developed informal seed system — and the initiative has spread rapidly.

Development and dissemination of the orphan crop variety *Quncho* shows how S&T can deliver new varieties using participatory, inclusive and context-appropriate innovations.

Professor Tim Benton discusses issues around how to shape sustainable agriculture Breeding new crop varieties is only one of many options for resource-conserving and yield-enhancing agriculture. While the S&T of variety development is amongst the most visible innovations in agricultural science, a number of other innovations in crop management are promoting sustainable intensification by conserving resources, building environmental quality and increasing yields.

Crop management systems

Agroecology is developing new systems of crop management that increase yields while conserving resources. It is particularly effective at increasing food production while improving environmental and social outcomes. Agroecological methods rely on management rules and packages of technologies carefully calibrated to suit local conditions and farmers' preferences. Methods include systems such as agroforestry, conservation agriculture, the system of rice intensification, integrated pest management, the inclusion of aquaculture and small livestock into farming systems, water harvesting, soil conservation and integrated nutrient management.

A 2006 analysis of agroecological methods based on 286 projects in 57 countries in the developing world, showed that projects increased crop yields by 64 per cent on average while improving water efficiency and carbon sequestration and reducing pesticide use. [17] In 2009, agroecological methods were endorsed by the International Assessment of Agricultural Knowledge, Science and Technology for Development, a process consulting some 900 participants over three years. [18] These new management systems, and new crop varieties, promise to enable the world to produce more food while conserving resources and protecting the environment. But more needs to be done to further develop these approaches and examine their potential. There is controversy, for example, about the yield-increases reported by proponents of the System of Rice Intensification and the methods used to evaluate the outcomes of agroecological practice. [27]

Agroecological innovations for sustainable intensification

Agroforestry:
Agroforestry incorporates trees or shrubs into cropping systems, offering a range of benefits such as replenishing soil fertility and providing food, fodder, timber and fuelwood — and so helping produce greater value than single crops. [19] The system's potential is most powerfully demonstrated in the Sahel, where agroforestry supported by soil and water conservation has 're-greened' the desert. In Niger, for example, five million hectares have been rehabilitated, benefitting some 2.5 million people. [20]

Agroforestry can also increase yields substantially. In Burkina Faso, for example, planting trees and shrubs on farms across 200,000–300,000 hectares of farmland has boosted food production by some 80,000 tonnes a year. In Cameroon, maize yields have increased by 70 per cent on average, where leguminous trees and shrubs were planted on croplands. [21] Across Africa, using 'fertiliser tree' systems has increase the yields of food crops such as maize while reducing the use of expensive inorganic fertiliser. [22]

Integrated Pest Management (IPM):
IPM combines targeted use of agrochemicals with growing practices and biological techniques to control pests. Assessments of IPM show that it is possible to improve crop yields while reducing overall pesticide use. An assessment of 62 IPM initiatives in 26 countries revealed a 35 per cent increase in yields of various crops, alongside a 72 per cent decrease in pesticide use. [23] An innovative new IPM system, called 'push-pull technology' has been developed by Kenyan scientists in collaboration with UK researchers to control pests (notably stem-borers and *Striga* weed). It attracts pests to nearby plants (*pull*) while driving them away from the field using a repellent crop grown among the farmers' main crop (*push*). This system is now widely deployed across Africa — an estimated 30,000 smallholders in Kenya, Uganda and Tanzania use it. In a recent assessment of push-pull IPM, researchers report 3–4-fold increases in maize, 2-fold increases in sorghum, improved soil health and increased farm biodiversity. [24]

Conservation agriculture (CA) and the *System of Rice Intensification (SRI)*: CA consists of three interlinked principles: minimal soil tilling, maintaining permanent organic soil cover, and cultivating diverse crop species. CA was first developed in Latin America, and is now practiced on around 106 million hectares of arable and permanent crops. SRI, based on principles such as minimal use of water and transplanting of young seedlings, is widely used across Asia, Latin America and Africa, and has resulted in substantial yield increases while improving water-use efficiency. SRI benefits include 20-100 per cent or more increased yields, up to 90 per cent reduction in required seed, and up to 50 per cent water savings. [25] Both of these management systems may contradict conventional advice from agricultural research institutes and the agriculture service, and often clash with what farmers think works best. [26] For example, cultivating SRI rice involves an unconventional irrigation schedule where fields are periodically drained rather than perpetually saturated. However, applying them while involving farmers as co-creators at every stage can help both farmers and research and extension agents to engage in creative and transformative change, rethinking established practices and exploring new ideas. [26]

Participation is key

It is clear that innovation by itself is not enough to ensure increased food production, resource conservation or social-ecological well-being. Farmers, rural workers, local groups and community leaders need to participate in innovation, rather than being treated as passive recipients of new technologies. Participatory models work — a recent analysis of 40 cases of sustainable intensification of agriculture in Africa shows the ways in which farmers, public and private -sector partners have developed, adapted and disseminated agroecological systems that have increased yields while delivering environmental and social benefits. [15] All the cases highlight the importance of farmer engagement, peer-to-peer learning, and of developing and using local institutions.

Professor Tim Benton on building links between researchers in the global north and south There is no single technical or managerial fix to the interlinked problems of global hunger, poverty and environmental degradation. The role of S&T will be one of developing a diverse menu of options which farmers can use, share and tailor, providing a range of social, economic and ecological benefits over and above increased productivity.

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Hunger Index Map:

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Science Writing in the Real World

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Introduction

This article addresses the question 'how are scientific and technical articles to be written'? This is possibly easier to answer for the youngster in training than for the seasoned practitioner, hopefully not because old dogs can't be taught new tricks but because universal prescriptions are elusive.

Review

Why is 'writing' important? In the technical world, writing remains the primary means of communicating plans, actions and outcomes. Writing out the conceptions so others can follow has the benefit of clarifying the thinking, it acts as the blueprint for implementation, and it captures the experience upon completion. Writing and action interdepend. If the written plan is defective so will be the action. If the action is ineffective, honest writing must report that. As the teaching adage goes 'if you can't say it (or write it), it's not worth knowing'. Both the developed and developing world share the paradox of youth unemployment yet skilled job vacancies, not least in engineering, science and technology. The implication is that we are failadequately to school enough professionals in the art of saying or writing it to the extent that it is worth knowing.

Are there any rules?

In his classic book Against Method Paul Feyerabend objected to a single prescriptive scientific method on the grounds that this would limit scientists' activities and thereby constrain progress (Feyerabend 1975). This need for idiosyncrasy is not confined to science. In the business world there is the requirement to differentiate products and services – to deliberately make them distinctively different so as to get noticed and make sales. This carries through even to business management in which if, say,

Acme Widgets adopts the same management style as its competitors it will then perform the same as them and not become superior. Acme Widgets needs a different if not better management system to be competitive. Does idiosyncrasy extend from method to write-up? When I started university teaching I had a firm idea of how science was done, and written up. My students soon cured me. They came up with approaches that did not fit teacher's prescription, but worked nonetheless.

Years later, as a mature student sitting at the back of the MBA class and paying attention not only to the lecture content but also to the lecturer style, it was evident that 'this is how it is done' did not generate the interest, learning and progress that 'how do we solve this problem?' did. Might our main question be answered by surveying the readership to ascertain its wants, needs and expectations? The survey results would certainly be interesting, and they would not be irrelevant. But they might just not produce the ultimate answers. To enlarge on the points already made about novelty, consider the following. The market did not perceive a want, need or expectation for the iPod, iPhone and iPad. The market did not anticipate anything like these gadgets, and surveying potential consumers would not have pointed to these innovations. Before they were invented there was no market for the gadgets. It took the technical know-how and artistic flair of Steve Jobs to dream up the gizmos with which the market fell in love.

Similarly, and obvious on reflection, a scientific discovery is new because no one thought like that before. The discovery will need to be communicated, and it will need to satisfy a market demand – pre-existing or self-created – if it is to be generally adopted. There are problems though. Implications of 'against method' include that if anything goes, then everything stays, and all methods are of equal merit. This is dubious, and evidently not any method will 'fly' though beforehand it might not be possible always to distinguish the useful from the useless.

Further, there is a contradiction. 'Against method' is a method of sorts. Surely there are at least some high level boundary conditions to writing business, scientific and technical articles? Surely there are minima – pretty well universal requirements of the sine qua non type – such as 'there must be a purpose or problem that the writing addresses'? Surely there must be maxims – operating rules – to be adopted, such as 'never write for fools'. Some suggested minima and maxims are offered below.

Purpose and problem

A foremost minimum is that the work must have a clear purpose, preferably stated at the outset. This might seem an obvious requirement. But surprisingly often the purpose is not up front or it is confused or both. In one recent case the stakeholders objected that the purpose of the project plan did not appear until page 14 of a 78 page report. There is an asymmetry between reader and writer about the purpose of an article. The writer has foreknowledge of what she is writing, while there is a limitless range to reader preconceptions, so the reader sets out without knowing what is important in a rambling 14-page introduction. In today's world where there is so much exciting stuff, the reader might not have the patience to get to page 14. To help the reader, tell her the purpose at the start and then, if necessary, explain. Most such explanations are incomplete or an infinite regress of justifications – my purpose is to solve problem P because P affects sustainability, and sustainability is a principle supported by the United Nations, and

the UN was formed to support harmony and wellbeing, and harmony and wellbeing are pillars of civilized society, and so on. Often with natural resources and people there are many conditions to be met. This poses problems with the ostensibly 'clear purpose'. Even if the case of optimizing among multiple goals can be solved mathematically, in practice – be it written or actual science or technology – this is difficult. Usually the multiple goals get listed without prioritization, and conflicts, contradictions and indecisiveness arise. For example, the water release schedule from the dam specifies a flood be released on 31 August every year. The World Bank, who funded the dam construction, insists on compliance. But the Environmental Panel says that a 'blue sky river flood' is not expected by either the downstream biota or people and therefore that the stated objectives of perpetuating the natural river and protecting the riparian people are not met. Hence, unless there is rain on 31 August – highly improbable – dam operators suffer managerial paralysis for fear of the wrath of the Bank or the Panel. One approach to the multiple conditions is akin to linear programming. Set a single objective function but subject to constraints or boundary conditions. For example, I say to my mining clients that the objective of mining rehabilitation is to minimize the cost subject to the following conditions: land capability meets specification c, landscape form meets specification d, soil loss is within limits e, soil fertility meets specification f, and so on. Without having to master the maths of linear programming, miners can identify with this type of objective. Minimizing cost makes intuitive sense. Each specification can be developed, measured, reviewed and revised independently, and measurement on all specifications, and of the cost, can be combined to show overall performance.

The approach helps to highlight weaknesses and show where attention is needed to improve management and even understanding and method. It all accords with the adage 'if you don't measure it you can't management and improve it'. A further aspect to the purpose of an article is that it addresses a problem or constraint. If you want to do something, figure out what is holding you back, and fix it. If my car will not start it does not help to fill the half empty fuel tank when the battery is flat. In applied fields such as agriculture, environmental science and forestry, orientation around real world problems is pretty well a matter of course. In academia though the problems tackled are not obvious to some of us – filling the fuel tank instead of charging the battery. True, some inventions were made without any thought to application, and at some institutions there is a strong ethic of academic freedom – 'we do not prescribe to you how and what to teach and research, and you are granted tenure on the basis of the regard your peers have for you'. It is nevertheless contestable that laissez faire approaches are more fruitful than ones directed at worldly problems. Taleb (2004) would probably say that perceived fruitfulness of laissez faire is 'fooled by randomness' – let loose a large number of academic geeks and some are expected to discover something by chance alone. Kahneman (2011) could argue WYSIATI

(what you see is all there is) – the many miserable failures are not recorded so we don't see these and bring them into our cost-benefit reckoning.

Testability

Science and technology have in common the qualities of repeatability and testability. The same instrument or method must yield a repeatable result. A hallmark of written science and technology is that every statement is capable of being tested and capable of being shown to be wrong. The testing would firstly be in the mind, at the time of reading, and secondly in physical reality if the reader were so moved. An example of a statement that does not meet the criterion of testability is 'it usually rains just before, at or just after new or full moon'. This prediction can never be found wanting since there is a new or full moon every fortnight so most of time is covered, and the qualifier 'usually' caters for the few days distant from the lunar events. A requirement that every statement is testable relieves the need to provide proof or authority for every notion expressed. Giving proof and citing authority for every statement is of course tedious. But there are more serious difficulties. First, there are limits to substantiation. Positive proof is logically impossible – you can only disprove or, failing that, corroborate. And substantiation can become an infinite regress in search for an illusory ultimate authoritative source. Second, absence of evidence does not mean evidence of absence, as in the case of Taleb's (2012) turkeys being fat, flourishing and untroubled by any grounds for downfall, until a few days before Thanksgiving. Third, insisting on an authority for every statement precludes new ideas, therefore suppresses discovery and forecast of catastrophe, and may defeat the very purpose of science.

Message reliability before content

Kahneman (2011) makes a point that professionals, even those with statistical expertise, have exaggerated faith in small samples, and pay undue attention to the content of messages without cognizance of their reliability. Kahneman and Taleb have recently popularized this issue on which, to their credit, reviewers for top journals have long been vigilant. These people have rendered a service to humanity by emphasizing the overlooked role of chance in our lives, the WYSIATI phenomenon, pseudoreplication, the irresponsible adoption of short-cut statistics like chi-square and Kruskal-Wallis instead of measuring actual sample variability, and so on. Unfortunately the Kahneman-Taleb popularization of probability theory, and its strict observance in top journals, are, surprisingly, rarely the case in the applied field where the stakes are high and can run into US$ billions. Megaprojects, and the reports that motivate them, are conservative on cost estimates, optimistic on benefits, heedless of risks, and guilty of adopting EGAP (everything goes according to plan) when the individual probabilities of each of the issues is low and their combination in the best scenario a remote possibility. The prudent approach, too rarely applied, is to determine the 'most likely development' (MLD) which itself is subject to deviation. Little wonder that megaprojects typically turn out 150% over budget

or worse (Fleyvbjerg et al. 2003). The want of applied probability theory extends beyond megaproject planning to common project construction and operation, and to day-to-day applied and even academic science. A typical case is that of river management and instream flow requirements in southern Africa. Study and monitoring are by means of sampling. Single samples are taken at so-called representative sites at intervals over time. Even if a site is indeed representative of its river reach at the time of site selection, this representativeness might not endure because of changing riparian conditions, altered land-use in the catchment, water abstraction and effluent discharges. Many supposedly representative sites are chosen on, among other criteria, accessibility. Such sites are also accessible to vehicular traffic with its attendant pollution, to livestock that drink and urinate, dung and muddy the water, and to people who visit to picnic or wash or fish or dispose of rubbish. The criterion of accessibility is a virtual guarantee that the chosen site is not representative of upstream and downstream. But there is in any case no measurement of representativeness, and indeed no estimate of sampling variation within times as a baseline against which to compare sampling variation between times. The upshot is that the resulting data, sometimes costing US$ millions to collect, do not meet a long-standing criterion of good science, namely that it permits strong inference to be drawn (Platt 1964). In the case of the applied and academic situation, grass cover is another example. It is notoriously difficult to measure. The poor measurability of the parameter limits the confidence that can be attached to inferences regarding the relative merits of experimental and managerial treatments. Much of southern African rangeland theory hinges on how management increases or decreases basal grass cover, but because of the low repeatability of cover measurement (Mentis 1981) the theory, though not necessarily mistaken, is more a matter of belief than hard science. Rangeland science and management, and other areas in the natural resource field, would forge ahead if there were quick and cheap means of testing alternative scientific hypotheses and management treatments. In other words if grass could be measured quicker, easier and cheaper then our turnaround with experiments would speed up and more confidence might be attached to results. This doubtless applies in many other instances. Grass cover has fractal properties, like the famous case of coastline length (Lesmoir-Gordon et al. 2006) where the same pattern is repeated across spatial scales. As you scale up the coastline you see the same pattern of bays and peninsulas. Measuring coastline length depends on the scale or resolution, and walking along the water's edge would yield a shorter length than a snail following the water's edge. With grass, as resolution increases, there is a repeating pattern of clusters: colonies, tufts, tillers... Increasing resolution does not improve data quality because the density and shape of clustering is fuzzy and variable, and the interpretation of 'hit or miss' with the measuring tool (usually one or other type of sharp point that is lowered into the sward and watched to see if it strikes a cluster) is subjective and poorly repeatable at whatever scale. One option in this kind of circumstance is not to hike up

resolution and complexity by resorting to gadgetry such as Tidmarsh Wheels and Levy Bridges, and sophistications such as distance between the nearest and second-nearest plants, but to scale down and simplify, permitting, albeit with a rough and ready technique, collection of large amounts of data quickly and cheaply. For instance, grass cover can be rated by striding through the sample area and scoring, at every fall of the right foot: 5 (lawn), 4 (nearly a lawn), 3 (more grass tuft than bare ground), 2 (more bare ground than grass tuft), and 1 (very sparse to bare). In one application of this simple approach it was possible for one 67-year old worker to collect 1500 30-point samples along a 555 km fuel pipeline construction servitude in one month, and to survive the ordeal to be able to draw strong inferences on improvement or otherwise in grass cover between one year and the preceding year. Another common mistake in doing science and writing it up is an unquestioned assumption that statistical significance is absolute. This is especially so in monitoring studies. Strictly, the demonstration of statistical significance depends on several factors: the absolute size of difference between compared means, on the sampling variability, and on the number of samples. The demonstration of statistical significance in scientific articles and project reports is commonly a fortuitous outcome of arbitrarily chosen sample size in relation to sample variance and the nature of the experimental or managerial treatments, with no consideration of what constitutes a material difference. For example, the mean soil P of 1 mg/kg at site A might – by the sampling design used – be statistically different from mean soil P of 2 mg/kg at site B, but the difference would be immaterial in the context of growing a pasture of subtropical grasses which needs a soil P of at least 15 mg/kg. A better way of proceeding is first to determine the amount of change in the parameter of interest that is material. Then a pilot study should be undertaken to determine sampling variation The appropriate sample size, N, can then be estimated by calculating

$$N = 2 x s^2 x t_{0.05}^2 / (X_1 - X_2)^2$$

Where s^2 is the variance determined by the pilot study, where s $t_{0.052}$ is the value of t in Student's t-distribution for the appropriate number of degrees of freedom and X_1 - X_2 is the chosen size of material difference. To illustrate, in the above example of rating grass cover, given X1 - X2 of 0.5, with s typically at 0.5 and the t-value assumed equal to 2, N works out at five 30-point samples. It arises that the requisite data to test for a material difference in grass cover can be collected by one worker in less than an hour. This compares favourably against Tidmarsh Wheels and Levy Bridges that might need to be carried kilometers by a team up hill and down dale, operated on steep and rough terrain, and for which thousands of point observations might be necessary to assure confidence in results.

Parsimony

A cornerstone of science and technology is parsimony. No description, experiment, explanation, hypothesis, idea, instrument, machine, method, model, prediction,

Figure 1 Schooling student in determining the vagaries of sampling. Designing an appropriate statistical test requires pre-specification of the size of material difference and knowledge of sample variance in order to calculate the requisite sample size.

Table 1 How to survive a turbulent world

Dimension	Syndrome	
	Antifragile	***Fragile***
Complexity	Parsimonious	Comprehensive, holistic
Data dependence	Key indicators	Data intensive, measure everything
Expertise	Operable by generalist	Need trained specialists
Insight	Relies on first principles	Rests on history & precedent
Interdependency	Parts can function independently	Parts function only interdependently
Paradigmatic	Uses 'pure' data	Rich in special models & theories
Redundancy	Staff inter-changeability	Each staff with specialized function
Structure	Fragmented	Monolithic

On a range of structural and functional dimensions organizations and systems can be prone to failure (i.e. fragile), or be designed to be robust (i.e. antifragile).

statement, technique, test or theory should be more elaborate than necessary to satisfy its purpose. On the precedent of reviewing countless postgraduate theses, scientific articles and technical reports, the body language of the writing, as judged on such criteria as parsimony, reflects the effectiveness of the execution, be that experimenting, modeling or monitoring or whatever.

Where the writing is not concise and precise, digging deeper in the document usually reveals the same shortcomings in the planning and execution. The ground rules to modeling capture the essence of the point here. The rules are very explicit: start simple, the simplest model that might work, and add complexity later if necessary (Starfield et al. 1994). There is no logic to starting with a complicated model. For example, where would one start? There is no upper limit to complexity. And it would be wasteful to include any more than the essentials. The raison d'etre of modeling is to exclude all but the bones of the subject issue. Yet in project after project what happens? The cognoscenti propose methods and models of amazing complexity, with all kinds of bells and whistles. Maybe the consultants and contractors, having vested interests, want to make the job big and complicated to seem clever or make more money. Examples in southern Africa include rangeland and river condition assessment and management. The condition measurement involves, among other things, identification, if not measurement of abundance, of, for example, every plant, macro-invertebrate and fish taxon. This is unrealistic for many reasons. The ordinary professional can master identification of a few species, but few people are experts on a whole biota. Even for the few prominent species, knowledge of response to perturbation is skimpy. For the many lesser species we simply do not know so their inclusion in a model just adds noise. In the developing regions of the world the taxonomy of the biota is uncertain, and it can be difficult to put a name to many a specimen. Within a group, like plants, species vary in form and abundance, so the one-size-fits-all sampling method doesn't produce reliable data. Then unreplicated sampling is done at fixed sites, of unknown representativeness, as explained above. Regardless of the uncertainties, the results are plugged into the great model that spits out a condition which is of unexplored sampling variability. If the complicated exercise were repeated tomorrow, or 50 m away, or at a randomly selected sample site, how different might the result be? How different must the result be to matter materially? In few cases does anyone know. Cost-effectiveness, and likelihood of ever being actually applied, could be improved by simple testable models involving a few indicator variables for which can be designed specific measuring techniques to yield reliable data. In most projects that I review the monitoring recommended by the consultants never gets done because it is too all-embracing and complicated and at a cost outweighing the benefits that could accrue if the consultants' recommendations were followed. Simplicity of technique in modeling or monitoring or whatever is not the same as being simplistic. To the contrary, devising a simple and effective method is really challenging.

The applied situation often has severe constraints, including limited resources of time, budget and manpower, and events that threaten the best laid plans. Because one is in the applied situation, where unanticipated costs can run into US$ billions, does not mean any lesser standard. Indeed, 'done at the highest intellectual level' always applies. This leads on to Taleb's notion of antifragility (Taleb 2012). I say Taleb because he popularized appreciation that a system has a greater or lesser capacity to withstand shocks, and this capacity can be increased by exposure to shock. In fairness though, Holling and coworkers at the University of British Columbia developed ideas of system resilience and adaptive management in the 1970s. These phenomena apply across organizations from the human body to whole biotic regions. A few examples are as follows.

In the case of the 'smaller' organization, the marathon runner trains his body by stressing it. With a little stress the body responds and increases its capacity to tolerate more stress. If the stress is extreme and continued then the body fails – injury occurs. The athlete must walk the tightrope between over- and under-training. In life there are many applications of this principle of increasing our personal capacity by stressing the body thereby training it to improve performance. In the case of the 'bigger' organization, the African savanna and steppe have an amazing capacity to tolerate stress and disturbance, in the form of recurrent drought, fire, flood and herbivory. Earlier botanists working in South Africa considered that present grassland and savanna areas in the moist eastern regions were forest and scrub forest as little as 800 years ago, and it was only after the arrival of the Bantu that the woody vegetation got opened out by chopping and burning (Acocks 1975). However, it turns out that much of the savanna and steppe has been burnt every year or few by lightning or man and his predecessors, for millions of years – how else do we explain the biodiversity of the systems, the fire adaptations of many of the organisms, and the seeming need for the system to be burnt periodically that its biodiversity not be lost (Ellery and Mentis 1992)? Of course it is common knowledge that forest does not 'bounce back' like steppe and savanna when defoliated, and at least in some parts of the world forest patches are refugia. But even here there are interesting contrasts. Along the northeast coast of South Africa, and going north into Mozambique, the dune forest has remarkable recovery capacity, converging on climax species composition after disturbance (bull-dozing or dune mining) in as little as 54 to 70 years (Mentis and Ellery 1998). Perhaps unlike most forest regions, along the southeast coast of Africa chronic disturbance has been a feature over recent evolutionary and ecological time. Sea level has risen and fallen as a result of monoclinal titling and global warming and cooling, and tropical cyclones and fire have occurred with short return periods. In consequence, dunes have been built, vegetated and destroyed frequently, and the dune forest would be expected to be resilient to disturbance of this nature. In 1985 when I moved to the University of the Witwatersrand my predecessor, Brian Walker, now at CSIRO in Australia, mentioned that a high proportion of his postgraduates did not complete write-up of their

studies on schedule. Evidently EGAP (everything goes according to plan) is an optimism not only misplaced in the world of business and infrastructure projects, but applies also in science and academia. Scientific research, and its write-up, deliberately pursue uncertainties and unknowns, and therefore are predisposed to risks of EGAP failing. How does one satisfy the research supervisors and the funding agency that progress is being made, that the project is not falling behind schedule or off-target? One option is to plan and execute the research in a succession of small steps. One of my students, Christo Fabricius, adopted this approach. In his research into habitat suitability for a widely distributed antelope in southern Africa, the kudu (Tragelaphus strepsiceros), Fabricius first collected data on a wide range of plausible habitat determinants in relation to kudu presence and absence. He analyzed crudely using multivariate techniques of the correspondence analysis/ factor analysis type. Having identified variables with the highest correlations with kudu, he reduced the number of variables and collected better data. The study proceeded by these such successive approximations. The write-up then comprised stand alone 'chapters', yet the whole gave the history of discovery. A famous case of this approach was that of the grouse (Lagopus lagopus) research unit on the heather moors of the Scottish Highlands where initial hunches framed research which led to formulation of hypotheses that were then tested yielding more refined hypotheses for the on-going investigation. The successive publications over time told a fascinating story of unfolding knowledge of the determinants of grouse abundance.

Young researchers are misled when they read superb write-ups of scientific studies in foremost journals. The impression is of once-off brilliant design, expeditious execution and efficient yield of significant results. Not revealed by journals is a much messier reality, as described for example by Watson (1968). In our study of dune mining and forest recovery, Fred Ellery and I had to rerun our data collection and analysis to rigorously test the effects of mining (Mentis and Ellery 1998). A referee advised that we should regard mining/ no-mining as a dummy variable and then use multiple regression to see which of the many independent variables (including the dummy variable) significantly affected the dependent variable (species richness). I had heard of dummy variables previously but never seen a practical example. The application in this case showed mining was not different from other dune disturbances, and the overriding determinant in forest recovery was time since disturbance. Another interesting personal experience was in trying to test formative causation proposed by Sheldrake (1987). The hypothesis proposed that the first occurrence of an event created a precedent and thereafter, by a force called morphic resonance acting across any space, the event happened more easily. For example, after rats have learned a new trick in one place, other rats elsewhere seem to learn more easily.

To materialists this might seem implausible, but even physics, the bedrock of materialism, considers strange forces such as entanglement about which Einstein quipped 'spooky action at a distance'. My test of formative causation was to have

students learn random sequences of letters, test the students, provide a second set of randomly sequenced letters half of which had been learned before and half un-seen sequences, and test again to see if recall on previously learned sequences was better than sequences learned only once. I thought my test was definitive. But it failed. While most of the students learnt the random sequences in the rows of the matrices provided, as I wanted them to, a few 'Feyerabends' memorized the letters in columns, which I did not anticipate. My conception of the method of testing was at fault, and my intended statistical analysis invalidated. Of course I intended to repeat the test with better design, but yet again EGAP failed because I left the university and was denied easy access to cheap and biddable study 'rats'. Failed EGAP must happen often in research, requiring re-plan and re-run of the test. Such actual course of science is rarely documented in formal scientific writing. It is no wonder that learner scientists have the mistaken expectation of the once-off experiment or test that will quickly produces a publishable result or award of a degree. Evidently the trick with science is to iterate 'plan-do-review & revise'. The shorter and more frequent the iterations the less likely are unknowns to allow the researcher down blind alleys. Of course the 'plan-do-review & revise' applies not only to scientific research but all kinds of projects, if not to life itself. The notion of the project plan, or life plan, being a once-off definitive blueprint is illusory. No one can predict the future, and the bigger the future – as in the bigger the project – the more likely it is that EGAP will fail. This is not reason to abandon the plan. On the contrary, one must start with the best plan that current knowledge and circumstances allow. Then this 'best' plan must be updated, by the iterated 'plan-do-review & revise', at frequent intervals. Naturally the plan cannot afford to be a 500 page treatise that takes a year to revise. The compilation needs to be an expeditious succinct statement of – depending on context – objective, constraints, hypotheses and risks, and of the appropriate actions, controls and tests. To make it work there must be targets, the targets must be measured, and the folk involved must be rewarded for achieving the targets. The presentation – writing – of this is very demanding. But alone this repeatedly updated plan is not enough to excel, even just survive, in Taleb's 'world we don't understand' or the United States military's VUCA (volatile, uncertain, complex, ambiguous). Whether it is a business, infrastructure or research project, or even the individual person, it will benefit from being inured against 'the slings and arrows of outrageous fortune'. How might this challenge be approached? How is antifragility enhanced? Deliberately exposing the system to stress, and running antifragility drills (cf. emergency drills), are advised. But as entertaining and informative as Taleb's books and articles are, there is limited guidance on how to design organizational structure and function to avoid going belly-up in the face of turbulence. Can we remedy this? In Table 1 below fragility and antifragility are juxtaposed on a number of structural and functional dimensions of systems such as business, infrastructure and research projects. The reader is now invited to consider how to

design, execute and write up his or her next project, or personal plan for the next year.

Discussion

The thrust of argument in this article is that technical writing, and the action or system that it describes, must be purposeful, problem-orientated, testable or repeatable, parsimonious and antifragile. None of this is new, but surprisingly often – even in the case of megaprojects in which the stakes run into US$ billions – the minima are insufficiently applied in combination, both in conception, design and execution on the one hand, and in critical evaluation on the other. The typical project – be it research or real world – is too accepting of EGAP. The oversights arise in several ways. First is the inevitable caprice of random variables. There is super software such as @RISK (www.palisade.com) for dealing with this, but in the more than 20 years since I was introduced to this I have seen it used on projects only twice. Second, there are the non-random variables (streamflow is an example), non-linearities and contingent events that prompt Black Swans (unpredictable events of big consequence) that require antifragile properties to be designed in. Yet the norm is complex projects with critical interdependency of components and requiring omniscient and omnipotent demons to manage them for which MLD is 'too big to fail' with 'good money thrown after bad' in vain effort to rescue the image, pride and project. Third, and on a different tack, the project proponent does not engage the stakeholders and get their buy-in. The authorities and proponents reserve decision-making to themselves for they know what is best for us. They might inform the stakeholders, and invite their comment, but rarely do they obtain unbiased opinion by statistically designed surveys, engage in dialogue one-on-one or in forums, facilitate meetings of key stakeholders to have them decide their priorities, and involve them in decisions and implementation. The results are products that don't generate the forecasted revenues, trains without enough goods and passengers to make them pay, a road where it is not wanted and no road where it is wanted. There are some excellent guides on how to reduce these problems (Porter and Kramer 2006; Decker et al. 2012). And of course the critical commonality is communicating, for which skillful writing is an indispensable part.

Conclusion

In conclusion, writing remains the key medium of communication and the link between initial conceptions, plans, execution, outcomes, experiential learning, and the next project. With knowledge exploding, and there being ever more theories and facts, writing hasn't got easier. The challenge is to compile the succinct purposeful problem-orientated reliable parsimonious message. Developing nations and their young talent can surely do a better job than is the current norm.

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Bush Encroachment – Causes, Consequences and Cures

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Bush encroachment is the increase in biomass of indigenous woody or shrubby plants to the detriment of the herbaceous (grassy) layer. Different authors refer to the phenomenon by various terms, from "bush thickening", "woody thickening", "shrub thickening", the slightly more pejorative "shrub encroachment", to the (perhaps alarmist) "woody weed invasion", and "shrub invasion".

There has been some debate as to the best term to use, but "bush encroachment" and "shrub encroachment" are the most commonly seen in the literature, with up to 150 times more papers using "encroachment" rather than "thickening". Regardless of its name, managers have been aware of the phenomenon for nearly a century, and interest in its effects on both biodiversity and rangeland productivity has continued unabated. The problem occurs in savannas across the globe, and given that roughly 2 billion people live in savannas, the effects of bush encroachment could be devastating. Despite extensive global research into bush encroachment over the decades, we have yet to reach agreement on its causes.

This special edition on bush encroachment (causes, consequences and cures) in southern Africa draws together a set of research papers with some of the more recent findings on bush encroachment in this region, along with a thought-provoking review of the state of our knowledge, particularly in a southern African context.

African Journal of Range and Forage Science

Special Issue: Bush encroachment – changes, causes, consequences and cures

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Visual Obstruction as a Method to Quantify Herbaceous Biomass in Southern African Semi-arid Savannas

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Range specialists and wildlife managers often need quick estimates of biomass of above-ground vegetation to manage grasslands. In some instances, biomass estimates may not have been used as information to support important management decisions, because hand-clipping is very time intensive and has been viewed as the only means of arriving at good estimates of biomass. In similar situations, North American managers and scientists routinely use a visual obstruction method ("range pole" or "Robel pole") to provide a quick index to biomass, but this method has not been used in southern Africa. Our research in northern Namibia provided evidence that biomass could be efficiently and effectively predicted using the readings of visual obstruction. The method requires inexpensive equipment and little training. The pole used for visual obstruction is generally lighter than an alternative method, the disc pasture meter, and thus may be a preferable alternative for field workers. We believe that the visual obstruction method can provide useful information to support stocking decisions or management with prescribed fires. Visual obstruction data can also be used to describe trends in vegetation structure before, during, and after droughts as part of an efficient long-term monitoring scheme.

Fertilize with Nitrogen and Phosphorous to Maximise Tiller Production in *Themeda triandra*

du Toit, J. C. O. (2014). Growth and tiller production of Themeda triandra as affected by NPK fertilisation. *African Journal of Range & Forage Science*, (ahead-of-print), 1-4.

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Themeda triandra is a species of grass occurring over a wide rainfall gradient in southern Africa. Despite its abundance, it is notoriously difficult to re-establish in transformed environments, especially in high-rainfall areas where seed survival is low.

One option is to propagate *T. triandra* vegetatively – this is done by fragmenting tufts into individual tillers and planting these into seedling trays for about two weeks, whereafter they are planted where needed, or left to grow and then harvested for another generation of tillers. In this way, millions of plants can be propagated from a small starter population over a couple of years. The key issue is to maximise tiller production. A pot-experiment was conducted to find out how *T. triandra* plants grew in relation to the relative amounts of nitrogen, phosphorous, and potassium they received (none, low, and high, and all combinations). Low levels of fertilizer equated with fertilizer requirements of low production pastures, and high levels were ten times this. Plants responded well to nitrogen and phosphorous, with maximum tillers produced when both were applied at the highest level (approximately 500 and 50 kg per hectare per year for N and P respectively).

Mass per tiller remained approximately constant across all treatments, indicating that when adequate nutrients are available, plants produce new tillers rather than expanding the size of existing tillers. There was no response to potassium for any treatments.

Fire and the Dynamics of Two Unpalatable Grass Species (*Cymbopogon pospischilii* and *Elionurus muticus*) in a Semi-arid Climate

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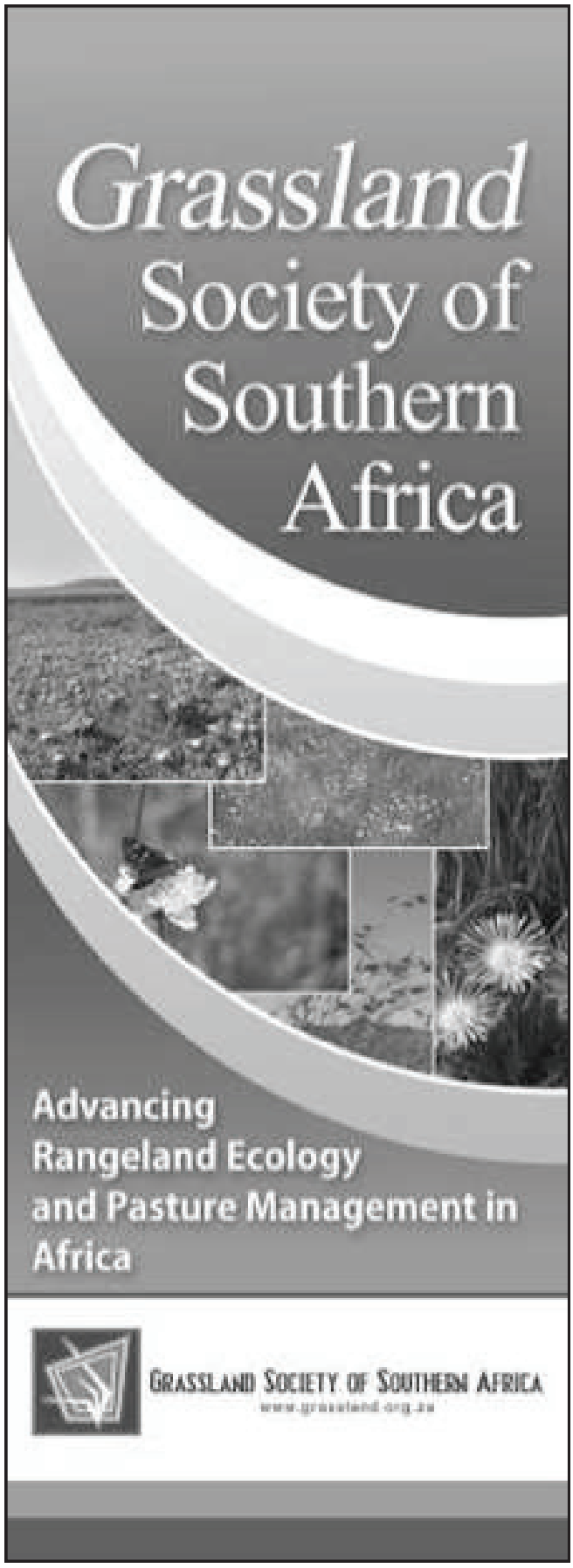
Cymbopogon pospischilii and *Elionurus muticus* are unpalatable for most of the growing season and form a reasonably large component of the vegetation composition in semi-arid grassland areas. The impact of fire on the environment is complex. Fire can seldom be isolated from its association with grazing. This association is responsible for much of the controversy surrounding the use of fire in southern Africa.

The influence of an accidental fire on the dynamics of these two grass species was quantified over a three-year period (2008/09 to 2010/11 growing seasons) in a semi-arid grassland. After burning, the production of C. pospischilii was still 18% higher than that of the total production of the rest of the burned species for the third growing season following the fire. Production of *E. muticus* was lowered by fire with 82% for the first season. Three years after the fire, the density of *C. pospischilii* was 14.52 plants m^{-2} versus an average for the unburned species of only 6.78 plants m^{-2}. Seedling emergence from the seed bank for *C. pospischilii* and *E. muticus,* at the end of the third growing season, was respectively, 6.6 (550%) and 12.4 (537%) seedlings m^{-2} more than that of unburned grassland - a reason for concern regarding plant composition stability of burnt semi-arid grasslands. This study contributes towards better understanding of the dynamics of the two unpalatable grass species (*Cymbopogon pospischilii* and *Elionurus muticus*) regarding sustainable utilization of semi-arid grasslands. As these species dominate in large parts of the semi-arid grasslands, correct management, whether burned or not, is essential for sustainable utilization of this grassland ecosystem. The sour grasses have a built-in survival mechanism in that they get the opportunity to complete their annual life cycle due to their unpalatability.

They seed and build growth reserves. By burning these grasslands the sour grasses are rejuvenated in spring by rescuing them from old material which would have led to smothering of the tuft, leading to an increase in tuft size of *C. pospischilii* as was observed in this study. Tiller populations of *C. pospischilii*, whose tillers survive a maximum of two years, are eventually eliminated

by complete protection from grazing because tiller mortality is marginally increased and tiller recruitment is suppressed. However, they increase under annual or biennial burning or annual harvesting, because the increased production of secondary tillers compensates for the increased mortality of harvested or burned tillers. By contrast, according to most researchers, *E. muticus* cannot successfully be "grazed out" nor "rested out" in the short-term.



Fire in the Eastern Karoo - Most Plants Resprout, But Some are Killed

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Fire is seldom a feature of the Karoo, a biome which occupies much of the western interior of South Africa. This is mainly because there is usually insufficient grass in this semi-arid shrubland to support fire.

At Grootfontein, the agricultural institute in the eastern Karoo, however, grassiness has increased over the past few decades, mainly owing to above-average rainfall. This allowed an accidental fire to burn several hectares of good condition veld in September 2012.

The fear, naturally, was that the fire would eradicate many of the Karoo shrubs so characteristic of this vegetation type. The finding was largely the opposite – of the 108 plant species that were found, 74 species resprouted after the fire, confirming fire-tolerance. This included all grass species, four geophytes, two ferns, woody shrubs, and succulents. Twenty-eight species had an unknown response to fire, mainly because they were rare, herbaceous, or non-perennial. Six species were nonsprouters (fire sensitive), all of which were Asteraceae. There were two species of *Eriocephalus* (kapokbos and doringkapok), two species of *Crassula* (succulents), a *Ruschia* (doringvygie), and a *Sarcocaulon* (kersbos). Whether or not these plants recolonise will be monitored in the future.

This research shows that the vegetation of the eastern Karoo is reasonably tolerant of fire. A new project, which will include a controlled burn, will explore the responses of species to fire in more detail.

The Sansor-Bayer "Science for a Better Life Award" bestowed on Dr Wayne Truter

Press Release

"Inside that tiny seed lives the roots, branches, bark, trunk, leaves, twigs and apple fruit of that apple tree. You can't see, feel, hear, taste or smell any of that yet; nevertheless, it is all inside that seed. The moment the seed is in your hand – all of that is in your hand, too, from the root to the bark to the fruit! All you have to do is push the seed into the soil. It is the belief that in a seed, there is a tree. So, believe! To have a seed, is to have everything." by a philosopher C. JoyBell.

Agriculture has been Dr Wayne Truter's passion since he was a little boy helping his father plant their first crop on a small piece of land many years ago. He shared that the smell of turned soil, the sound of rain, the sight of emerging seedlings, and the taste of a freshly buttered "mielie" with the feeling of completeness, enticed each and every one of his senses. That agricultural experience and many more to follow cultivated and sustained his interest in agriculture for life. This interest has kept him busy for the last 20 years in agricultural science, asking new questions, creating new thoughts, researching new ideas, testing new innovations and methodologies to ultimately share new outcomes. The past 10 years of his career, educating and training students at the University of Pretoria, has given him immense satisfaction. The knowledge of and witness to the massive contributions the graduates he have taught and supervised have made in the agricultural fraternity, acknowledge and recognise this passion he shares with and through many others.

The sciences of agriculture are lessons learned from nature, which supports the growth and expansion of life on earth. These past few years he has come to realize that many aspects of life begin with a seed. That seed may be the beginning of a life of an organism (human, animal or plant etc.) as we know it, but can be a thought that can create new ideas, new achievements or new scientific breakthroughs by new upcoming professionals. Not only have he had the opportunity to study the interrelationships between climate, soil, seeds, plants, animals and humans; he have been given the opportunity to work with young upcoming professionals, who are the new seeds of the agricultural fraternity in future. His career has taught him ways to convey the teachings of old and new knowledge, to the young and thought provoking minds that are driven by the accelerated technological advancements and innovations of engineering sciences that dominate our everyday life. Agriculture has had moments of negative connotation in South Africa and other parts of the world, and the glamor of this science has been

masked for many years. He can attest to the fact that once revealed it has proven to have had exceptional benefits indirectly and directly to many people. He says that he truly believes that the growth and development of agricultural sciences, lies in the ability and the passion of a young mind, that learns to nurture a seed, an idea, until it becomes a mature and recognized outcome. He has also learned that respect for an environment and another individual will grow one's mind beyond one's unknown limits.

The science of seed and the industry that revolves around it has provided him and his students with an understanding of the most important building block of life on earth. This science and industry is of major importance and can develop in many ways. In his particular field of expertise, Pasture Science, which is regarded by the Department of Education as one of the top agricultural scare skills in the country, is faced with serious educational and research challenges. These challenges have been discussed over the past couple of years in and amongst professional bodies, and actions taken have led to strategies to reduce the impact of the fading expertise in Pasture Science. It has been deducted that one of the reasons for the diminishing expertise and interest in pasture science, is the decline in interest in tertiary programmes that focus on plant breeding, genetics and seed biology just to mention a few. From a research perspective, it has been noted that information is readily available and easily accessible world-wide. First world countries that are leap years ahead with research on various aspects of seed science and other agricultural sciences, provide information that many third world countries use because of a shortage of local capacity and expertise.

This "Adopt and Adapt Syndrome" as he terms it, has often been to the detriment of some who have tried to apply locally untested methodologies. These cases alone, stress the need for locally relevant research, but can only suffice if supported by local industry, and if the importance of the seed industry is made known to young upcoming professionals. Once the passion and enthusiasm of interested students and upcoming professionals is captured, it should be nurtured. The research of technological advancements in seed science is of major importance, especially under variable South African conditions. Efforts to attract the interest of local industry, to support technologically advanced research locally, can often be challenging. Their research team however, has been very successful and the research being conducted and completed to date has provided some insightful outcomes which we regard as a positive impact to the seed industry.

Fundamental scientific research programmes are the main focus of tertiary and research institutions, however, commercial (production) research programmes and crop producer support programmes are scarce and ownerless at times in South Africa. This has resulted in retail companies taking ownership of the challenge, irrespective of the fact that research is not their core business, to ultimately provide some support to the producer.

As principal advisor to Grass SA, the aforementioned need was overwhelmingly identified in the pasture industry and has led to an exciting journey. This journey will focus on linking fundamental research outcomes produced by tertiary and research institutions, to practical implementation programmes and information valued by the producers and producer organizations. This concept was welcomed by the pasture fraternity and has given Grass SA the motivation and opportunity, to institute their first on-farm research station, which will serve the agricultural and in particular the pasture industry in future. In addition to the benefits of such an on-farm research station to pasture producers and organizations, its key objective is to provide graduates and young professionals from tertiary institutions, the opportunity for practical exposure and further mentorship. Through this innovation to achieve these goals, they can have a positive impact on the seed industry as well.

An additional impact on the seed industry is the positive contribution one needs to make to Human Capital Development through training and mentorship as previously mentioned. Human capital in the agricultural fraternity is easier to develop, when the glamour of agriculture and specifically to this industry, the importance of seed science, the magnitude of the seed industry and the impact on the agricultural fraternity is emphasised and marketed appropriately. As part of my efforts to do so, he regards it important to align ourselves as agriculturalists with other advanced disciplines, and by showing that agriculture is "hip", is "cool", is extremely complex and it is a crucial component of our everyday life, we will capture the interest and involvement of upcoming young professionals.

His training and research efforts the past few years, with the abovementioned objectives and aspirations in mind, have been fruitful through local industry support. It has helped to conduct high level research and to ultimately train and graduate numerous highly qualified young professionals who are the future of this industry. His career has fortunately provided him with the opportunity, to achieve the objective of germinating and nurturing the interest of seed science, amongst new students interested in agriculture, and in particular pasture science. It is important that highly qualified and upcoming professionals are trained to build this industry to new heights. For an industry to remain sustainable, it is imperative that professionals in this field have a basic scientific knowledge that can support their developing field and work experience. These attempts have been made possible in various ways and the passionate students identified in the past, mentored on various projects, and who are now the young professionals in industry, are testimony to the positive impacts human capital development can have on the seed industry.

Personally, just this nomination for the award has acknowledged and recognized, that the strategic goals and efforts made to achieve the aforementioned aspirations and objectives, are becoming a reality and it is just the beginning of new life in the agricultural industry as is a seed in soil.

Dr Truter will humbly use the prize money awarded to him to support his initiative of instituting a Young Agricultural Professionals Forum that will engage with all graduates entering or have entered into industry. It is envisaged that this forum will host exclusive evening business and technical seminars, motivational talks etc. It will provide young professionals the opportunity to interact with organizations such as SANSOR, other industry stakeholders and producer organizations and possibly assist them in identifying and meeting mentors.

To achieve some of these aspirations, he would enrol for an accredited life coaching / motivational speakers course, to ultimately equip himself with the knowledge of how to prepare a seminar, that I can present to young professionals in the agricultural fraternity, that attend a relevant conference and/or a proposed meeting of the upcoming Young Agricultural Professionals Forum.

Movers and Shakers

Tamara Hiltunen has moved from the Ezemvelo KZN Wildlife Biodiversity Stewardship Programme where she was a Biodiversity Stewardship Facilitator to ZuluWaters Game Reserve which was one of her sites. Her new role as the Conservation Manager sees her taking on the following responsibilities on the reserve: alien plant management, wildlife management, revision of the management plan, conducting of veld condition assessments, ensuring compliance with all legislation and stewardship agreements. Furthermore she is also responsible for overseeing our environmental services division which is involved in habitat restoration (areas cleared of dense alien plants and open cast mines) through landscaping and hydroseeding.