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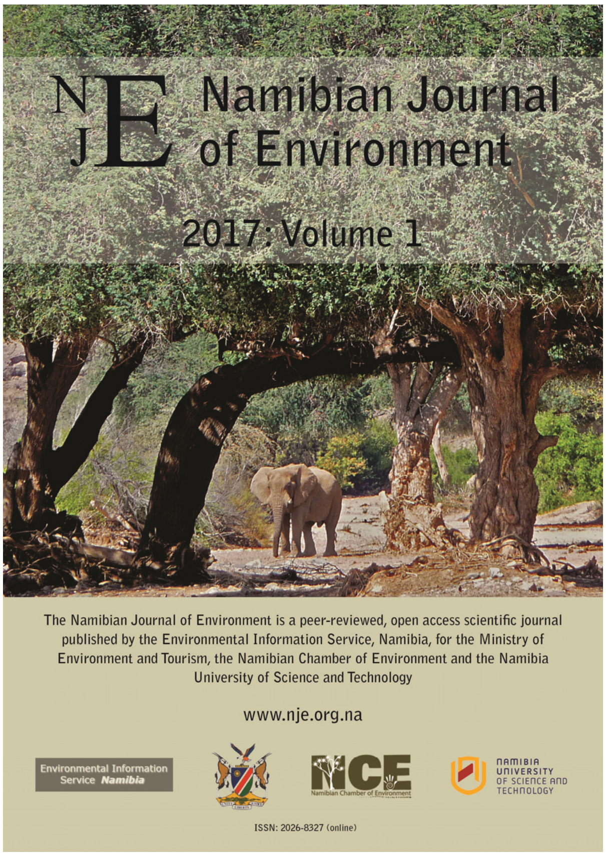

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Could critical Australian insights illuminate rangeland management in Namibia?

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Abstract

Climate change is now almost universally accepted as a reality and so too is the "hand of man". We are causing it. However, do we really understand (accept) what is causing most change or are we focusing huge amounts of money on politically correct (not "wrong") symptoms? Are greenhouse gases the real problem? Or is how we manage the land the problem and the solution? We put forward some propositions that beg a rethinking of the climate change issue, with a focus on better local land management for better local climate outcomes. We acknowledge that our evidence is based largely on a different way of thinking about climate change and local ecosystem health, but some case studies support this perspective and therefore require close scrutiny with an open mind. The core to our perspective is thermodynamics and the role of plants in that. Plants made our planet suitable for humans. We contend that the ecological malaise is driving climate change at a greater rate than industrial emissions and that the solution lies in land recovery. That is, if we want to address the causes and not simply the symptoms and convenient part truths. Enduring, self-sustaining, ecosystem rejuvenation is the key. We discuss how this can be pursued at a farm scale. We focus on key issues and how they can be addressed by systems thinking, rather than seeing the symptom as the core problem. Bush encroachment is such a symptom. We cannot change how brightly the sun shines, but we can influence how that energy is used, especially if we link it to water management and plant growth.

Keywords: bush encroachment, climate change, farming practices, Namibia, rangeland management

Introduction

In this paper we explore the potential for ideas developed by Peter Andrews in Australia (Andrews 2006, 2008) to help address key rangeland management issues in Namibia. We spent two weeks as a group exploring these ideas and their applicability in Namibia. While many of the ideas are challenging to our prevailing perspectives and paradigms, we urge an open-minded approach to test them. Surely it is more important to improve our rangeland management than defend it? The ideas we present below are essentially Andrews', but Pringle and Zimmermann see great potential to test these principles to restore natural fertilisation and rehydration processes in sub-Saharan Africa's most arid country. Do these processes also predominate beyond where Andrews has worked? Can they add value to what we are already doing based on decades of field experience? Probably!

The power of plants

We are all concerned about contemporary issues including global warming, increasing population demands on our planet, declining water supplies and increasing wealth inequality. These are apparently "wicked" problems that will require complex, complicated solutions – or so we are led to believe. What if the primary cause were also recognised as the solution? What if we poured our billions of dollars into correcting nature's own solution to perturbation instead of into disintegrated and disappointing investments whose most impressive outcomes only scratch the surface?

If one accepts that plants and water are both the problem and the solution, then we can bring focus to broad-scale, enduring change. Industrial emissions are minuscule in comparison to what we have done physically to our planet by clearing, overgrazing and "expert" burning. So, should we focus on the sideshow or grasp the problem by the jugular? We need to grow more plants and restore rain-use efficiency. We can do this on both sides of the ledger; by returning the filtering system which prevented our landscape fertility from being lost to the sea; by making it rain more and by cycling more of that rain before it escapes to the currently hostile (reflective) land that typifies most of our planet. As we have more water recycled by plants on the land, we trigger more rain.

It might sound crazily simple; and it is. Plants convert sunlight into carbohydrates, which requires energy; they transpire water in the process and so are landscape air conditioners and they cycle the nutrients for their diverse peers to maintain fertility. Why are we trying to fix everything else? The complexity is human; we have to revive our knowledge of how water and plants can provide very localised and then also continental landscapes that are naturally air conditioned and productive. Surely this is where we should be focusing our efforts to solve the supposedly intractable issues of our time?

Australia's landscape laboratory

Australia is the "old" continent in that it has experienced least tectonic instability and largely been free of glaciations. Wet (warm) and dry (cold) cycles led to Australian soils being mostly leached and infertile in the Tertiary era. Yet this aridity and infertility was overcome by what can only be understood as some self-organising force that evolved into ecosystems that redistributed water and fertility so that the overall ecosystem was more productive and resilient (Noy-Meir 1981).

The continent of Australia has experienced swings between extremes of harsh and lush conditions over the ages. As plants evolved to occupy land from the surrounding oceans, they gradually improved conditions over the millennia by creating soil, protecting the soil from erosion, moderating extremes of temperature, controlling the cycling of water and providing food for animals that contributed to nutrient cycling. The cooling effect of vegetation during daytime, as transpiration by plants, converted the daily heat to latent heat, and resulted in the land becoming cooler than the ocean. When the resulting vapour shrunk back to water, this caused moist air above the ocean to move inland, joining air above plants already moist from transpiration, causing condensation into rain. The densest vegetation grew in the lowest landscape positions, causing most of the water to flow around the dense vegetation on higher ground where organic debris was deposited on contour at the high-water mark, producing sills that formed steps in the landscape. This created a stepped diffusion hydroponic system that efficiently irrigated the land with slow flow of water through the root zone of plants and abundance of fire-retarding plants. This wonderfully efficient system managed itself through feedback systems in a well-balanced manner, without human intervention.

When humans first settled in Australia 60,000 years ago, they started to upset the balance, largely through burning of vegetation. However, when European settlers arrived around 230 years ago, they brought with them hoofed animals that destroyed vegetation at a much faster rate. This resulted in water flowing rapidly through the centre of valleys, eroding soil and cutting deep channels that facilitated the draining of the surrounding landscape. The bared soil was heated by the sun, resulting in the land often becoming much hotter than the ocean for prolonged periods every year, so blowing air with evapotranspired moisture onto the ocean and reducing rainfall over the land. Since such problems and worse had previously been solved by plants, the Australian landscape provides a laboratory from which the lessons learned can be applied to healing damaged land.

Applied solutions and potential for Namibia

Andrews (2008) has recreated the conditions for ecosystem self-management, making it possible to restore efficient water and nutrient cycles on some Australian farms. These successes provide good learning opportunities for application in Namibia, where hoofed animals have been present for a lot longer and land degradation has proceeded at a rapid pace.

When Andrews visited Namibia in September 2015, he toured through some rangelands of Khomas, Omaheke and Otjozondjupa regions, interacting with a few farmers and academics. During the tour, various questions and doubts were raised, needing to be answered and dispelled by practical application. The lessons learned during the tour are shared with readers in this paper. It was evident that as the week-long pre-tour of the Namibian Rangeland Forum progressed, those accompanying Andrews increasingly understood and accepted his perspectives. This was not always easy as it required accepting new, somewhat counter-intuitive ideas.

Core scientific principles of relevance to balanced landscapes

Balance created by diverse functional groups of plants

Non-edible plants that protect themselves with thorns or poisons perform an important function in rangelands. They return carbon to the soil, modified by diverse microorganisms in the form of a large variety of carbon compounds, many of which get taken up by edible plants. An outbreak of weeds or encroachment by woody plants is a symptom of mismanagement that leads to infertile soil, which they are trying to repair. If given the chance to restore fertility, the soil will once again support more edible plants.

Species of non-edible plants fail to grow well in soils with residue from their own species. This allelopathy prevents any single species from dominating the land, contributing to high biodiversity with each species serving a particular function. Where a single species of edible plant dominates a local area, it is usually maintained by fertility produced by non-edible plants on higher ground draining down to the location dominated by edible plants.

A high biodiversity of plants that forms a natural balance ensures that particular functional groups condition the soil for high production of good quality edible plants that support fast animal growth (Brunetti 2014). One of the means whereby plants of different species interchange resources is through common mycorrhizal networks that link the plant roots (Walder et al. 2012). High biodiversity also provides a "reserves bench" which buffers against perturbations that might adversely affect a small number of species (Walker et al. 1999).

Salt management

In a healthy agricultural landscape, salt is kept safely underground, under a layer of fresh water that keeps it there. This is achieved by a high diversity of plants acting as a solar powered pump lifting a balanced amount of minerals and carbon compounds to the surface and facilitating that the replacement water pushes the residual salt below the root zone (Andrews 2006). The removal of perennial vegetation has created salty badlands over vast areas of Australia, yet the focus continues to deal with the symptoms and not the causes. In rangelands, loss of coarse-textured topsoils also enables capillary rise of salt that didn't occur when topsoil pores were large and negated capillary action (Pringle 2002). Fortunately for Namibia, secondary salinity is not yet a major problem, but it does occur locally in lowlands denuded of perennial vegetation by overgrazing.

Atmospheric carbon cycling

If humans get to recognise the consequences of our destructive activities such as deforestation, we could use our wetland filters to replace the material we presently get from forest, which would contribute a 20% reduction in current atmospheric carbon accumulation. In the case of agriculture, if we could mulch farm like successful farmers did in the past but only a few are doing today, it would contribute a further 20% reduction by preventing oxidation of soil carbon and destruction of plant life. Industry (commercial activities that burn up fossil fuels) only contributes 3% to the current increased carbon dioxide level in the atmosphere. It is also reasonable to deduce that we could have some influence on the current natural 60% carbon cycling, possibly as much as 20%. This means that technically-aware humanity can have a 60% greater influence on the current situation. The result would be the moderation of climate, more quality food and certainly more water retained on the land. The difference between these two figures (10%) is the amount of the normal 60% recovery no longer being recovered due to destruction of plants. Oxidation has increased and recovery has declined due to increase in temperature, or failure to use the incoming heat from the sun (transfer from sensible to latent heat). Plants effectively can bring about a pre-industrial era carbon level in less than ten years if 30% of agriculture worldwide changed to mulch farming (the same as a good gardener uses a thick layer of plant residues to control weeds and water by virtue of evaporation loss). Mulch effectively conserves 100% conversion to soil carbon for later use by plants, compared to composting that is only 60% effective. We could test this at any scale by reproducing the process. The above figures are based on estimations at demonstration sites in the Australian landscape by Andrews, when re-instating the landscape's previous efficiencies.

Water cycling in landscapes

Attention is generally given to the effect of climate change on the water cycle, while insufficient attention is given to the inverse effect, of the water cycle on climate change (Sacks et al. 2014). In a healthy landscape, plants create a self-supporting climate. During the daytime, when plants transpire, they absorb heat. At night, much of the water vapour in the air condenses as dew, releasing heat to provide warmth. Hence the daily temperature fluctuations are greatly reduced (Pokorný et al. 2010). The condensation of dew on plants is facilitated by sharp tips on leaves and thorns that gather dew on their tips to run down stems and water roots. Under such conditions, 70% of the water that condenses as rain and dew originates from plants with only 30% originating from evaporation of seawater. However, currently 86% of the atmospheric moisture has been evaporated from the oceans (Kravčík et al. 2007). If land is wet enough then most of the evapotranspiration is from the land.

Fire control

Thanks to the natural water management by land and plants, fire was restricted to burn within the mosaic of land and water bodies. Because of the additional amount of atmospheric water, the fires did not achieve the level of heat that currently occurs, so most nights they would subside until becoming extinguished. Within the mix were always plant species that retarded fire, since the water vapour they released reduced heat to the extent that it could no longer sustain oxidation and their tissue lacked highly flammable oils. They lived together with companion plants on atmospheric water balance. However, animals then ate them out, changing landscape functions and resulting in artificial drainage (Andrews 2006).

It is illogical to assess a "desirable" fire regime based on the type of plants present at a site. They are a reflection of fire history, rather than the potential or desired vegetation. As a rule, the plants found in frequently and/or intensely burnt areas are of poor nutritional value to the ecosystem and livestock. Fire is often a short-term stimulant and long-term deficit process in terms of ecosystem productivity and herbivore nutrition. Feed the dung beetles, not the atmosphere!

Nutrient cycling in landscapes

Organic carbon compounds are the most influential nutrients in the environment, while minerals make up only a small percentage. Nutrients get moved by gravity either quickly if above ground or slowly if below ground, to the low filtering areas from where they used to get recycled back to higher ground by birds and mammals. Since humans have destroyed much of the fauna, both directly and indirectly, the nutrient recycling no longer takes place unless humans carry the fertility from filtering areas to the high ground. The nutrient cycle in a healthy landscape is coupled to the water cycle (Norris & Andrews 2010).

Conventional rangeland science does not include this upslope moving of fertility, but rather focuses on hierarchical patch dynamics, whereby the fertility and productivity are self-organised at multiple scales and levels of organisation in a topographic sequence (Noy-Meir 1973, Tongway et al. 2003, Pringle et al. 2006). Indeed, a clear example of upslope movement of fertility in Australian rangelands is that driven by wind (Gillieson et al. 1994). The upslope movement of fertility may well have been a key part of Australia's landscapes, but what if it wasn't, if it helps address the loss of topsoil and fertility that are well documented (McKeon et al. 2004)?

Stepped diffusion hydroponic system

This is a particularly contentious and important concept that needs to be well understood. In a healthy landscape, raw material tends to be deposited at high points so that it can be decomposed to soluble compounds moved by water to be combined into living matter. From lower points it needs to be transported back from where gravity moved it, a function that used to be performed by an abundance of birds and mammals. In the process, a natural sub-surface irrigation took place (environmental production line) facilitating an ability for the multiple compounds to be reorganised by many plant species and accompanying micro-organisms that fed the soil food web (Andrews 2008).

Most water and the sediments and nutrients it carried were diverted away from the densely vegetated valley and floodplain floors because water found it easier to progress downslope in slightly higher areas as a result of the thick vegetation and consequent obstruction to flow in the lowest areas.

The "steps" can be at a whole catchment scale, reflecting geological formations such as quartz and banded ironstone ridge gaps as with the Murchison River in Western Australia (Pringle & Tinley 2003), but they can also be at more local scales and based on soft sediments reinforced by vegetation in a positive feedback loop. It is this level of finer scaled water harvesting that is being lost from rangelands globally by poor grazing management (Tinley & Pringle 2013). In Namibia, local changes in the colour of the soil indicate where the "wet spots" used to be: the soil is darker due to retained organic carbon. They can be restored quite easily by helping rebuild the vegetation that allowed the subtle sills to develop. This can be done by placing anchored bush where the sill used to be and thereby regrowing the sill.

Case studies of sites visited

Mulch gardening

Vegetable gardens that were visited during the tour received irrigation water onto the soil from above. Since most of the gardens were located on gradients, even if very slight, the irrigation could be more effectively applied through a thick layer of mulch upslope of the vegetables, to allow water to pick up nutrients from the decomposing mulch and flow slowly past vegetable roots, permitting them to drink and feed as required. Long lines of drip irrigation could be applied along heaps of mulch in which creeping plants such as pumpkins could be grown, whose roots would assist in converting the lower layers of mulch to compost more efficiently than done in compost heaps (Figure 1). Key species for processing mulch include pumpkins, potatoes and tomatoes.

Figure 1: *Drip irrigation through thick mulch strips alongside which vegetables grow.*

Mulch for trees

Rather than placing irrigation basins around trees, a pond could be dug on the upslope side of each tree to be filled with mulch. The soil dug from the pond could be placed on each side as wing bunds to divert rainfall runoff into each side of the pond, cancelling out the energy of the flowing water from each side and allowing the calmed water to seep through the mulch and feed the tree roots slowly over the weeks after rain fell.

Bush mulch on contour

Along several of the roads driven during the tour were piles of bush that had been chopped in the road verges (Figure 2). Similarly, many of the rangelands driven past were encroached by bushes. If bushes were cut in strips along contour, the cleared bushes could be piled on the upslope side of the cleared strips where they would trap mulch and soil carried in runoff water, thus eventually creating a step in the landscape, below which the strip of grass would slowly receive nutrition from the bushed strip upslope. The bush mulch on contour would be ideal for growing edible bushes and trees in, so that they could be protected from herbivores until large enough to withstand occasional browsing. They could be planted either by seed scattered into the bush line, or seedlings transplanted into it, or cuttings or larger truncheons planted among it. If planted as seedlings, the longstem tubestock method of raising and planting the seedlings would ensure better survival (Australian Plants Society 2010). Cut bush can also be used to construct filters that divert water flow away from gullies.

Figure 2: *Bush lines provide good opportunities for establishment of edible plants, especially if aligned on contours.*

Recreating stepped landscape

Apart from recreating steps in the landscape by bush mulch placed on contours as described above, ditches can also be dug on contour to speed up the effectiveness of controlling water and nutrient recycling in the landscape. If water that would otherwise flow into pans or dams is instead diverted into contour ditches on either side, the water remains higher in the landscape and is encouraged to seep slowly as in-ground water. This conserves water far better than allowing it to evaporate from exposed pans or dams. Spillways could be constructed where the contours loop around ridges, to spread the spilled water safely onto high ground, maximising its spread over the ground below. If the contour ditches are widened at spillways to form a settling pond, the water is calmed before spilling and can further pick up nutrients if mulch is placed at the outlet of the settling pond. Trees on the higher ground will create the fertility to slowly move downhill to settle in depressions from where plants could be harvested for returning the fertility uphill, if there are insufficient birds and mammals to perform that task.

Revegetating bunds

Bunds are usually constructed from dug soil that is heaped in lines (Figure 3), sometimes referred to as mounds, banks or berms. Bunds constructed on the downslope side of contour ditches provide the opportunity to grow grass to stabilise the bund. If the bund is built wide, with its downslope side having a low gradient, and if a shallow (less than 30 cm) ditch is dug below it to collect runoff from this bund slope as well as some of the water spilled over spillways, then water will be available for both the grasses grown on the bund and trees grown below the bund. When the ditch fills, the water spills over the length of the ditch, calmly. Mulch pits can be located on the upslope side of the contour bund to process and spread mulch along the bund's length to release in-ground fertilised water.

Figure 3: *Water from a rain shower of 11 mm is held back in a contour ditch with bund for growing useful trees in a fruitful landscape.*

Diversion ditches on contour rather than on gradient

Diversion ditches had been aligned at a gradient of 1:200 to bring runoff water from surrounding land to a 30 ha fruitful landscape (Zimmermann et al. 2015). During the tour, Andrews pointed out that such gradient ditches do not appear in balanced nature. His advice was to construct the ditches on contour instead, with the ditch deeper in the direction of where the extra water needs to be moved. In this way, the spillage during intense rain would occur equally along the contour, rather than at a weak point to which the fast-flowing water would otherwise be directed.

Pulsing release of water

Where pipes are placed through dam walls to allow water to trickle through slowly (Figure 4), it would be more effective to place a valve at the outlet, so that the stored water could be released in pulses as happens frequently in nature (Middleton 1999). This also avoids unnatural waterlogging of soil that would otherwise become anaerobic and unproductive. In case water is held in a contour ditch and could be syphoned over to lower ground, the opportunity also exists to alternate the locations from where the water is released, as happens in nature by reeds growing where water previously escaped, thereby blocking further releases there.

Figure 4: *A pipe in a dam wall provides opportunities to pulse the release of water to favour grass growth, if fitted with a valve at its outlet.*

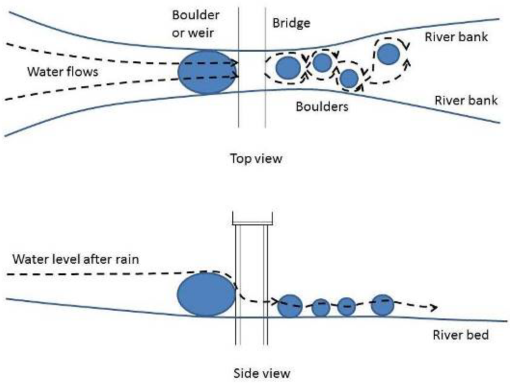

Figure 5: *Diagram of infrastructure above and below bridge to speed flow under bridge and absorb energy of the flow below the bridge.*

Opportunities provided by bridges

Road bridges usually occur in the narrowest sections of valleys (pinch points). The water upstream of a bridge can be made to flow more rapidly under the bridge, such as by constructing a weir or placing a large boulder to cause the water to drop steeply before flowing rapidly under the bridge. By facilitating the speeding of a larger quantity of water than the original channel, a much greater volume of water may pass per unit of time under the bridge. On the downstream side of the bridge, boulders placed at alternating sides cause the water to flow in a figure-of-eight pattern around them, absorbing the energies of the waters flowing on each side, thus calming them (Figure 5). Varying designs can achieve as much as seven times the volume of water under the bridge and it is then possible to use that energy to create a wave below the bridge that automatically exerts back pressure, helping to support bridge installations and preventing the water from gaining enough energy to erode the downstream area for a considerable distance.

Conclusion and recommendations

The visit by Peter Andrews has generated interest in the potential that Natural Sequence Farming methods have for Namibia. What is now required in Namibia is the building of capacity to test these ideas and opportunities This might best be achieved through a visit to Australia by interested Namibians and then a return visit from Andrews once some of his core ideas have been tried out in Namibia. All of the ideas need to fit within a more holistic management context regarding how infrastructure and grazing are planned and managed.

It is also recognised that any national, let alone international initiative, needs to respect and acknowledge the work of others who address these issues. Natural Sequence Farming has great potential, but is focused on some key issues that can be complemented by others' work. However, the focus on rangeland restoration is important to Namibia and builds on existing work and understanding.

Finally, can we farm better? Benign neglect as an illusory strategy for global conservation and deforestation, burning of fossils fuels and so forth has created this crisis. To use our planet wisely, we need to manage our fundamental energy source (the sun), the water cycle and nutrients. Plants will be the key. For Namibia, why don't we focus on these key functions for local outcomes. And why don't we find partners in Australia and elsewhere who accept that we can "farm the planet" back from the brink?

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