Understanding rangelands as dynamic catchment ecosystems

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Abstract

There are many factors that affect rangeland productivity and how it is channelled through "natural" and livestock components of food webs. There are pastoral programmes that address many of these factors quite specifically, be they commercial or taxpayer funded. In all of them, there is much good substance. The fundamentals of managing stocking rate and so forth are as relevant today as ever. What may be lacking in all of them is an understanding of rangelands as more than static mosaics of country types, though this appreciation is not structurally excluded from some programmes. Given that pastoral production depends on primary plant productivity and that this requires positive soil moisture balance, should we not also look at what drives patterns of soil moisture balance and how this can be enhanced? This ecosystem appreciation of how to manage the factors driving primary productivity has global significance.

Introduction

Rangelands as catchment ecosystems

The key point about seeing rangelands as catchment ecosystems is that rangelands are complex and land managers and the ecologists who support them require understanding of patterns and processes that are both top-down (e.g. geomorphology and geology and consequent soil types and landscape qualities) and bottom up (e.g. a small landscape incision eating away a whole sub-catchment). This understanding is old (Clements, 1916; Cowles, 1901), but was not prominent in building rangeland ecology (Sampson, 1917; Dyksterhuis, 1949). It is as important to manage the interactions of country types and their different strengths and weaknesses as to focus on managing them *per se*. Terrain sequences of run-off (uplands), run-through (pediments and valet sides) and run-on (bottomlands; floodplains etc.) offer different patterns of plant growth and vary within.

Base-level incision drives much rangeland degradation

A base level may be hard (a rock bar across a river) or soft (sediments supporting a floodplain's wetland). Base levels control the level to which erosion can proceed upslope by "holding up" the landscape and in so doing supporting surface water above to stay locally in key parts of a small pan, or major river floodplain (Pringle and Tinley, 2003). When base levels are breached, they initiate erosion and landscape dehydration in much the same way that erosion occurs when sea levels drop.

This critical, physical landscape factor is largely overlooked. In all rangelands with effective surface drainage in which I have worked in the past twenty years in Australia and southern Africa, base level incision (King, 1963) and cascading headward gully retreat is etching out most productive landscape process elements (Pringle and Tinley, 2003). This etching removes precious topsoil and allows water to flow out of eroding landscapes more easily. What isn't appreciated is that valley floor incisions can "suck" sequences of landscapes draining down to them and degrade whole sub-catchments to the extent of sheet flow. Natural 'run off' surfaces such as hills and big outcrops will always run-off most water, but landscapes that should harvest (valley sides) or capture (local bottom lands) surface flows are now also essentially becoming increasingly dominated by run-off processes (Shamathe *et al.*, 2009).

Base level incision is only one factor. Clearly, unplanned or excessive grazing pressure drives degradation too. It would be quite wrong to suggest that poor management practices can be sustainable, if one simply addresses landscape rehydration. This is just another leg of the "sustainability stool", which falls over without all being strong.

Rangeland dehydration is the least recognised and understood foundation of sustainability (Pringle and Tinley, 2003). It is driven by base level incision and exacerbated by overgrazing (unless unpalatable species emerge to retard loss of topsoil and resilience). Dehydration is initiated where surface flows find a nick point or cut in the landscape, be it a cattle pad or access track and thereby find a path of lesser resistance to flow. This physically "sucks" water out of the landscape.

Unfortunately the cut in the land, be it only a cattle pad of a few centimetres depth, acts as a point for upslope erosion that will follow the main source of flow over erodible sediments and split wherever flows from upslope converge. Thus "hydra heads" develop and gather pace, sending fingers out to steal increasingly more surface water. A minor incision allowing a small amount of water to exit locally more easily initiates cascading and accelerating incision and landscape dehydration.

Soil moisture balance determines conditions for plant growth - and is declining

Soil moisture balance (SMB) relates to the amount of moisture held in a soil and available for plant uptake. Incised landscapes facilitate run-off and so reduce infiltration. This changes fundamentally the conditions for plant growth and vegetation formation (Breshears and Barnes, 1999; Tinley, 1982). In rangelands generally, lower peaks and less persistent levels of soil moisture favour types of plants which are generally less nutritious, what is not understood is that these patterns are changing (Pringle and Tinley, 2003) .

"Woody weeds" are seen essentially as being a competitive outcome within local soil profiles, driven by overgrazing of "desirables" and replacement by "undesirables" (de Klerk, 2004; Noble, 1998). However, "undesirables" of quite different plant form to the diminishing "desirables", be they saltbushes or Mitchell grass, are telling us that soil conditions for plant growth may have changed, but this is quite landscape specific (Pringle and Tinley, 2003). To treat all of these areas as simply a "woody weed" problem may lead to a focus on symptoms, rather than causes (Pringle *et al.*, 2009).

Soil moisture balance is critical to conditions for plant growth and so the primary productivity that drives the complexity and stability of food webs, with or without livestock.

It is not monitored directly and a strong argument can be made that it is not monitored at all effectively indirectly by Government monitoring sites, with their biases towards “calm” areas of least local productivity and importance to ecosystem functioning (Pringle *et al.*, 2006).

Rehydrating landscapes

In many, if not most cases, base levels need to be restored to support returns to natural flows and patterns of soil moisture balance. It is therefore critical to recognise that any gulley system has etched its way back upslope from an incision point. Gullies need to be stopped to rehydrate resilient landscapes. There are few rangeland properties on which EMU has worked where there aren’t many gully systems dehydrating key landscapes, irrespective of tenure. It therefore becomes an issue of “bang for the buck”; identifying the most treatable areas that threaten most valued habitats and landscapes.

Conclusion

If patterns of soil moisture balance indeed influence primary productivity and can be enhanced or degraded by land management, perhaps the critical hydrological parts of catchments (Pringle *et al.*, 2006) need to be a focus of management and research? Degraded landscape productivity reduces carrying capacity, be it for human subsistence, livestock or biodiversity or any combination. We need to put the plug back in the bath and shut down the canals dehydrating rangelands to restore options.

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